

# ZEXEL

## FOREWORD

This manual is intended as a reference for workshop personnel who repair and maintain the PES-K type of fuel injection pump for small diesel engines. Construction, operation, disassembly and adjustment procedures are explained here.

The illustrations, drawings and specifications in this manual are the most up-to-date at the time of publication. Specifications and service procedures are subject to change without notice.



## OUTLINE OF PES-K TYPE PUMP

The PES-K type fuel injection pump was developed by ZEXEL as a fuel injection device for small engines used for small construction machinery, agricultural machinery and generators etc. The PES-K type in-line injection pump consists of a camshaft, roller tappets, plungers, delivery valves (the number of which equals the number of engine cylinders) and the variable speed governor installed in the housing.



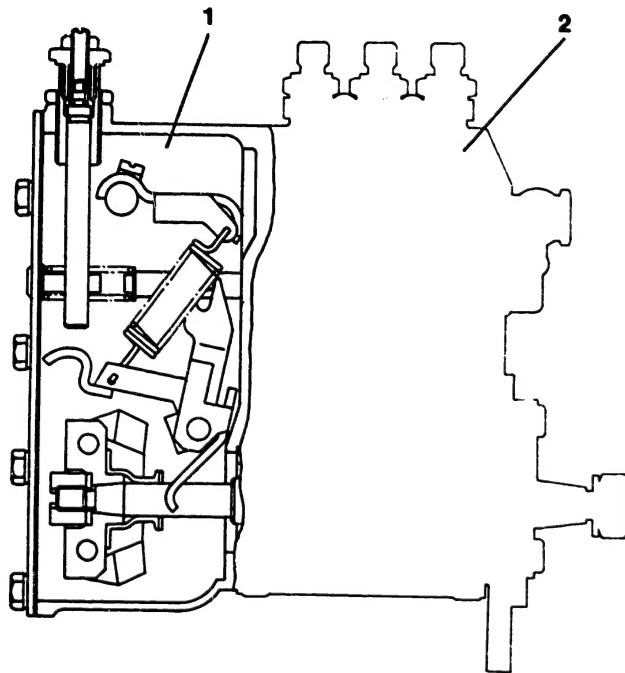


Fig. 1 PES 3 K pump

- 1 = Governor
- 2 = Injection pump

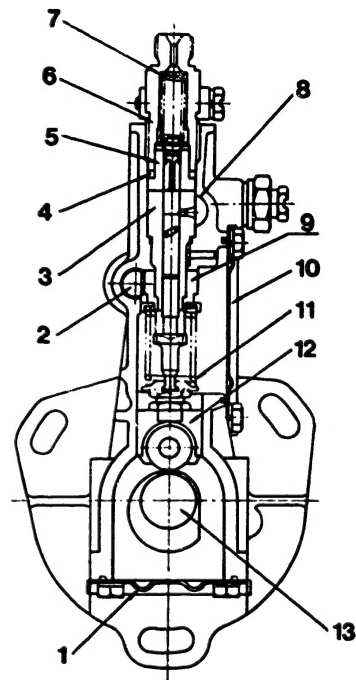


Fig. 2 Cross-sectional drawing of injection pump

- |                           |                     |
|---------------------------|---------------------|
| 1 = Cover                 | 9 = Control pinion  |
| 2 = Control rack          | 10 = Cover          |
| 3 = Plunger               | 11 = Plunger spring |
| 4 = Gasket                | 12 = Roller tappet  |
| 5 = Delivery valve        | 13 = Camshaft       |
| 6 = Delivery valve holder |                     |
| 7 = Delivery valve spring |                     |
| 8 = Pump housing          |                     |

**A3**

Outline

PES-K fuel injection pump



**A4**

Outline

PES-K fuel injection pump



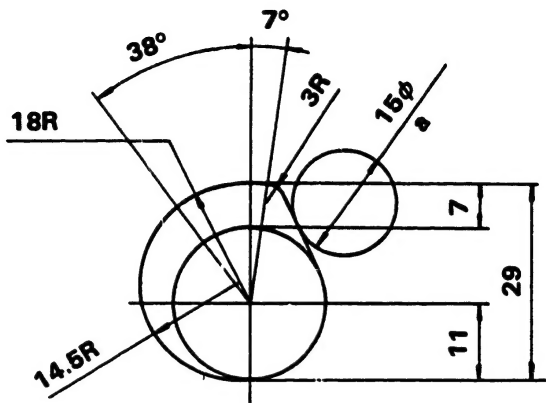


Fig. 3 Camshaft

$a$  = Roller



## Technical data

Number of cylinders: ..... 2, 3 or 4  
Rated plunger diameter ( $\emptyset$  mm) 5.0 - 7.5  
increasing in 0.5 mm steps  
Standard retraction quantity of  
delivery valve ( $\text{mm}^3$ ) ..... 25, 35 or 43  
Rated delivery  
    Minimum controlled injection quantity  
    ( $\text{mm}^3/\text{stroke}$ ) ..... approx. 5  
    Maximum allowable injection quantity  
    ( $\text{mm}^3/\text{stroke}$ ) ..... approx. 50  
Plunger stroke (mm) ..... 7.0  
Control rack travel (mm) ..... 14.6  
Maximum allowable speed (rpm) ..... 2500  
    (The maximum allowable speed can be  
    obtained when our standard cam profile  
    is used (see Fig. 3))  
Maximum allowable in-pipe pressure  
( $\text{kg}/\text{cm}^2$ ) ..... 300  
Governor regulation (%) ..... min. 4.5%  
Recommended oil ..... Light oil, SAE 313a



PES3K

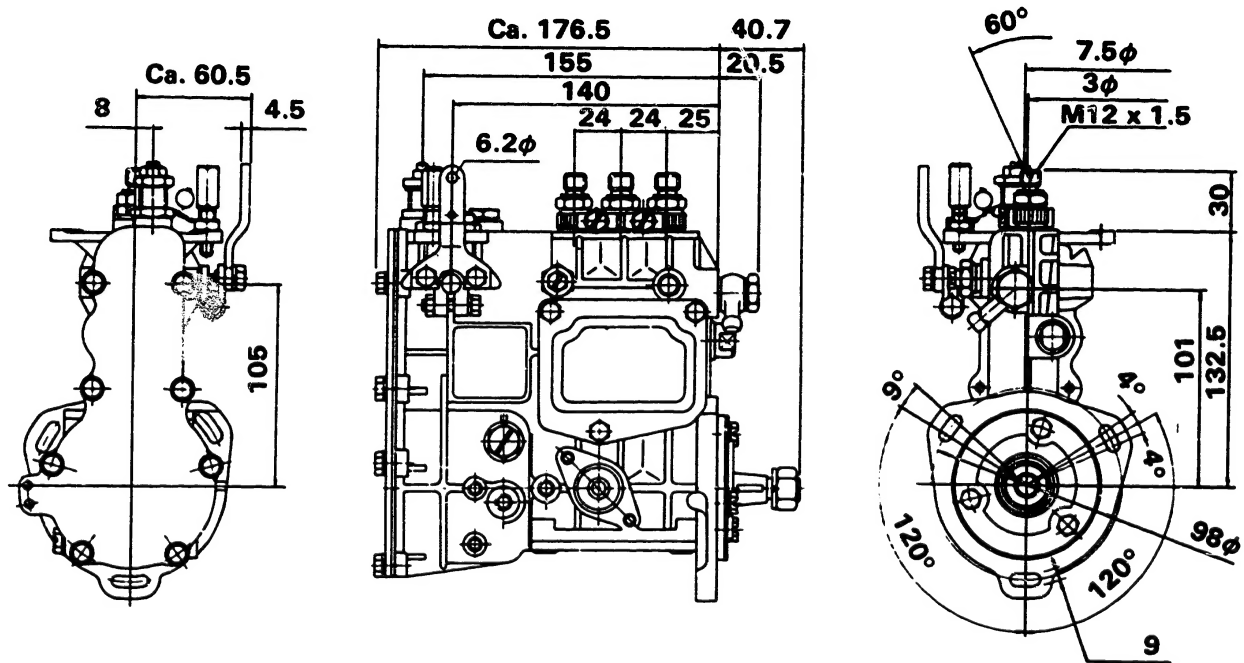
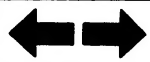


Fig. 4

Dimensions (all dimensions in mm)

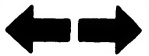
A7

Outline  
PES-K fuel injection pump

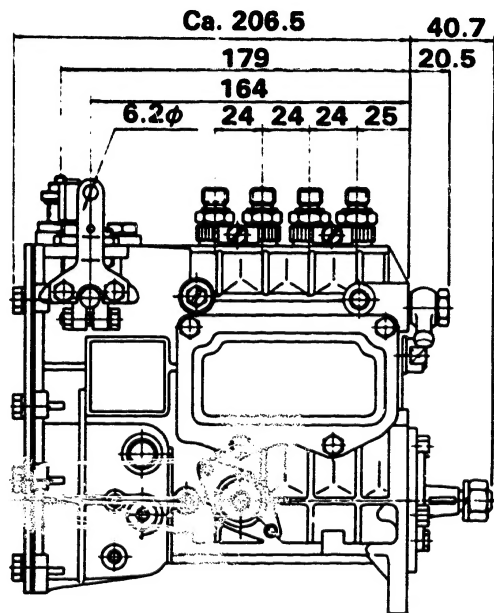


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Outline  
PES-K fuel injection pump



PES4K



PES2K

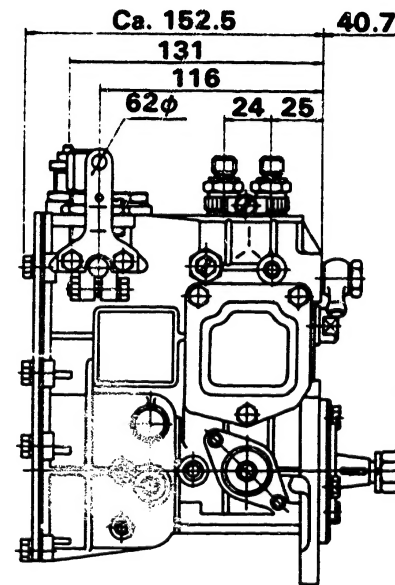


Fig. 4-1

Dimensions (all dimensions in mm)

A9

Outline

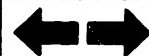
PES-K fuel injection pump



A10

Outline

PES-K fuel injection pump



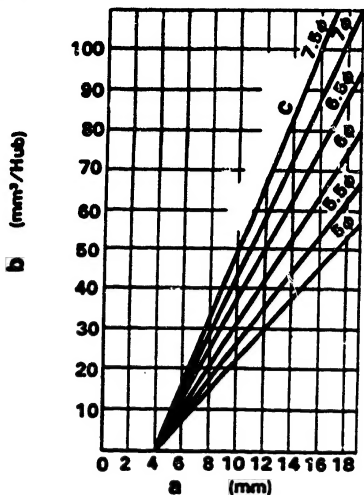


Fig. 5 Characteristic delivery curves

a = Control rack travel

b = Injection quantity (mm<sup>3</sup>/stroke)

c = Plunger diameter

Technical data:

Plunger lead: 12 mm

Retraction volume: 35 mm<sup>3</sup>/stroke

Cam lift: 7 mm





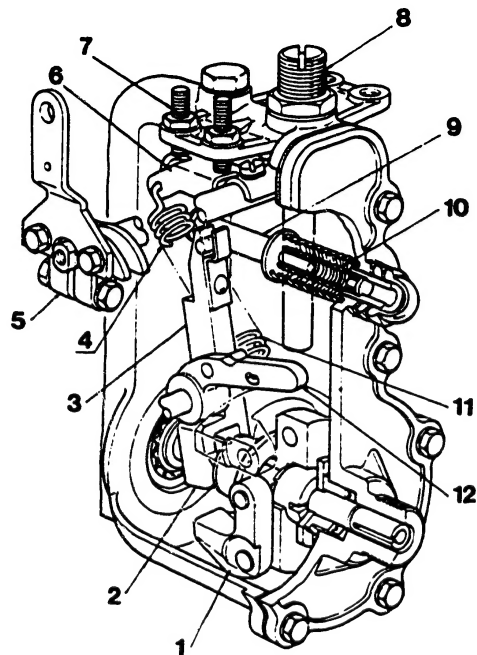


Fig. 6

**GOVERNOR CONSTRUCTION**

- 1 = Flyweight
- 2 = Sleeve
- 3 = Guide lever
- 4 = Governor spring
- 5 = Control lever
- 6 = Swivel lever

- 7 = Maximum speed stopper bolt
- 8 = Full-load stopper bolt
- 9 = Control rack
- 10 = Start spring (large)  
Idling spring (small)
- 11 = Tension lever

- 12 = Output shaft to tachometer

**A12**

Governor Construction  
PES-K fuel injection pump



**A13**

Governor Construction  
PES-K fuel injection pump



## Governor Construction

As pump speed increases or decreases, the flyweights of the mechanical governor attached to the camshaft open or close causing the roller of the mechanical governor to move in an axial direction. The sleeve attached to the end of the camshaft moves with the roller, transferring the sleeve movement to the guide lever. The shaft pin is located at the center of the governor. Guide lever and tension lever movement is around the shaft pin. The pin, which is press-fitted to the control rack, engages in the top of the guide lever. The start spring, attached to the end of the control rack, is used to increase the fuel injection quantity when the engine is started. The start spring exerts a constant pressure on the control rack in the fuel injection quantity increase direction. When the control rack is moved towards the governor, i.e. in the direction which decreases the fuel injection quantity, the control rack is forced against the idling spring. The control lever at the upper part of the governor is connected to the accelerator lever in the operator's compartment by a rod. The swivel lever is attached to the control lever shaft and responds to shaft movement. The governor spring is attached to one end of the swivel lever opposite to the control lever end. The tension lever is attached to the other end of the governor spring.

**A14**

Governor Construction

PES-K fuel injection pump



## Governor Construction (Continued)

The engine speed is determined by the tension of the governor spring. Tension lever movement is limited by the full-load stopper bolt. The stopper bolt position limits control lever movement and determines the maximum engine speed and idling engine speed. An output shaft to drive a tachometer may be provided on the governor side. The tachometer allows the engine speed to be monitored from the operator's compartment.

**A15**

Governor Construction

PES-K fuel injection pump



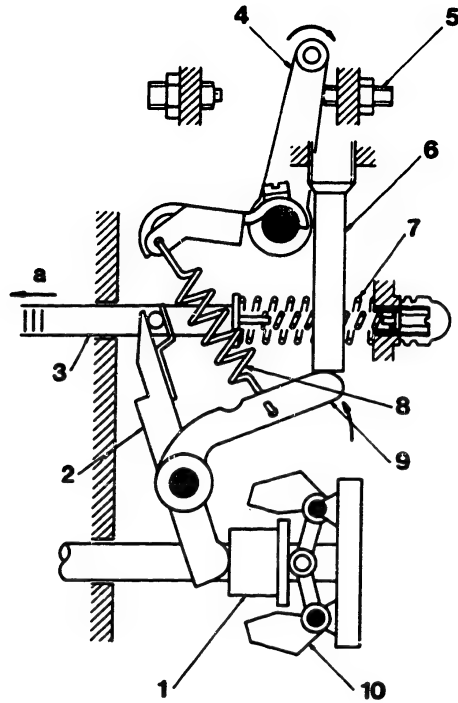


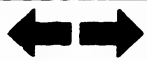
Fig. 7

**GOVERNOR OPERATION**

**Starting the engine**

- 1 = Sleeve
- 2 = Guide lever
- 3 = Control rack
- 4 = Control lever
- 5 = Maximum speed stopper bolt
- a = Fuel increase

- 6 = Full-load stopper bolt
- 7 = Start spring
- 8 = Governor spring
- 9 = Tension lever
- 10 = Flyweight



## Starting the engine

Operate the accelerator lever so that the governor control lever fully contacts the maximum speed stopper bolt. This will cause the tension lever to contact the full-load stopper bolt, and the control rack to move to the full-load position (Fig. 7). The control rack is then moved in the fuel injection quantity increase direction by the start spring. Under these conditions, the engine starts easily, and the centrifugal force acting on the flyweights gradually increases. When the centrifugal force exceeds the start spring force, the sleeve starts to move the guide lever as shown by the broken lines in Fig. 8. This causes the control rack to return to the full-load position.



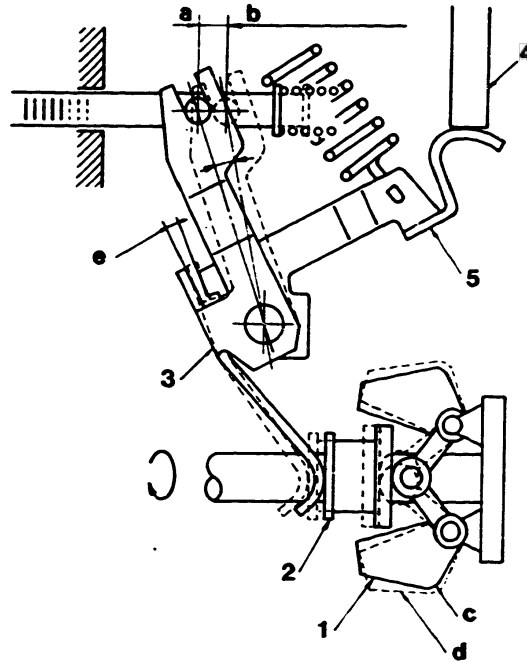


Fig. 8 Starting the engine

- 1 = Flyweight
- 2 = Sleeve
- 3 = Guide lever
- 4 = Full-load stopper bolt
- 5 = Tension lever

- a = Engine start position with increased fuel injection quantity
- b = Full-load position - stroke for increasing fuel injection quantity at engine start
- c = When the engine is stopped
- d = When the engine is operating
- e = Clearance angle

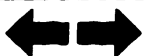
**A19**

Governor Operation  
PES-K fuel injection pump



**A20**

Governor Operation  
PES-K fuel injection pump



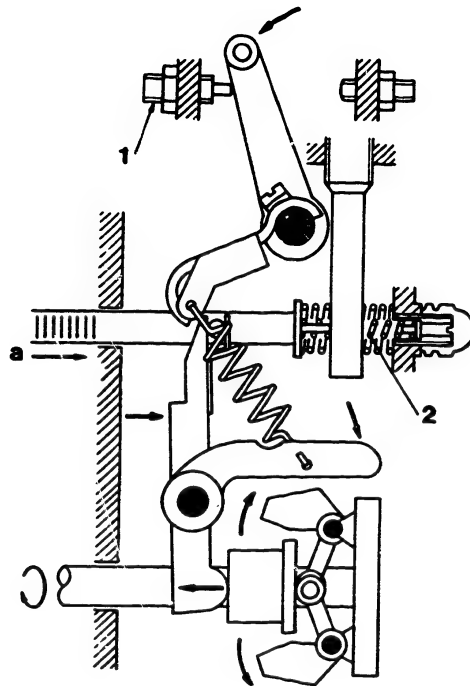


Fig. 9

- 1 = Stopper bolt
- 2 = Idling spring

a = Fuel decrease

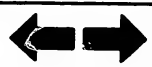
Idling operation

When the accelerator lever is returned to the idling position, the control lever contacts the stopper bolt and the governor spring is relieved. The centrifugal force acting on the flyweights exceeds the governor spring force, and the sleeve moves the control rack in the fuel-decrease direction.

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Governor Operation

PES-K fuel injection pump



A22

Governor Operation

PES-K fuel injection pump



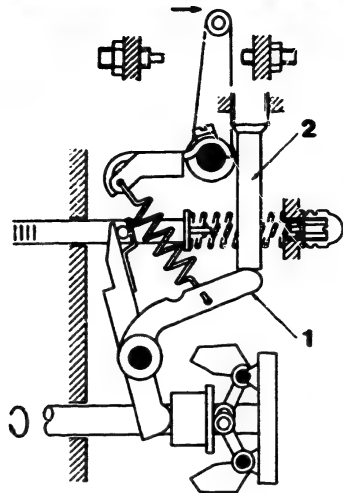
## Idling operation (Continued)

As the control rack compresses the start spring, the engine speed decreases and the centrifugal force is reduced. This causes the control rack to be positioned at a point where the centrifugal force and idling spring force are balanced. This ensures a steady idling operation.

**Note:** Some injection pumps are not provided with an idling spring. In such pumps, a governor spring controls idling operation.







**Fig. 10**

- 1 = Tension lever**
- 2 = Full-load stopper bolt**

**Normal operation**

When the control lever is moved towards the full-speed position, the tension lever contacts the full-load stopper bolt and tension is exerted on the governor spring. The guide lever, which follows the tension lever, moves the control rack towards the full-load position. The fuel injection quantity is increased, and engine speed increases. The engine speed increases until the centrifugal force acting on the flyweights balances the governor spring force, where the engine will operate at a steady speed (see Fig. 10).



## Normal operation (Continued)

When the load decreases while the engine is operating with the control lever in the same position, the engine speed increases. The centrifugal force therefore also increases. The flyweights (by way of the sleeve and tension lever) pull the governor spring and cause the guide lever to move the control rack in the fuel-decrease direction. Consequently, the engine speed decreases until it again reaches a steady speed.

On the other hand, if the engine speed decreases due to an increase in load, the governor functions to compensate for the engine speed decrease and return it to a steady speed.



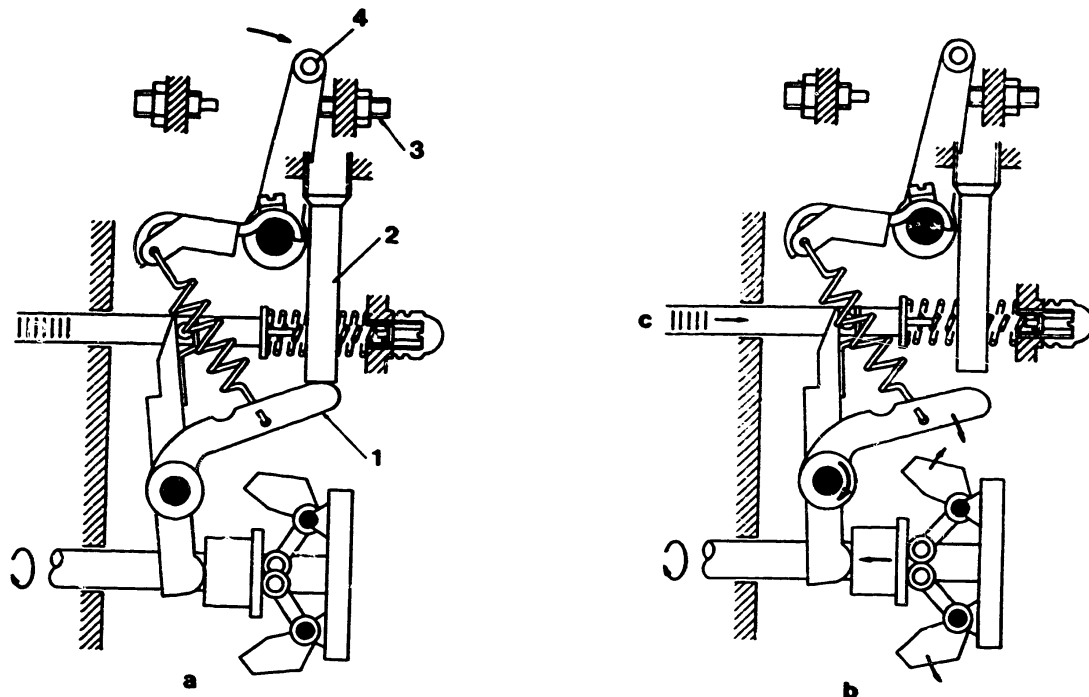


Fig. 11

Maximum speed control

- 1 = Tension lever
- 2 = Full-load stopper bolt
- 3 = Maximum speed stopper bolt
- 4 = Control lever

c = Fuel decrease

When control lever contact with the maximum speed stopper bolt is maintained, as shown in Fig. 11a, the engine speed will increase. As the engine speed increases, the centrifugal force also increases. However, the flyweights cannot open outwards, since the governor spring force is in excess of the centrifugal force.

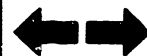
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Governor Operation  
PES-K fuel injection pump



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Governor Operation  
PES-K fuel injection pump



## Maximum speed control (Continued)

When the engine speed increases further, the centrifugal force exceeds the governor spring force, the flyweights open outwards and then push the guide lever to move the control rack towards the governor as shown in Fig. 11b. The fuel injection quantity is therefore reduced. This prevents the engine from operating above its maximum speed.



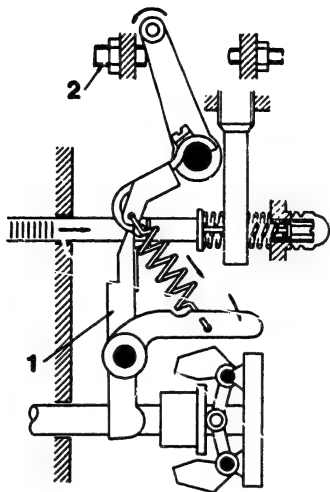


Fig. 12

1 = Guide lever

2 = Stopper bolt (spring capsule)

#### Stopping the engine

When the control lever is moved beyond the normal idling position, so that the spring inside the stopper bolt is compressed, the swivel lever and governor spring move together to their lowermost positions. This causes the tension lever to likewise move to its lowermost position. The guide lever, which follows the tension lever, moves the control rack in the fuel-decrease direction until the control rack reaches the non-injection position.



## Stopping the engine (Continued)

This stops the engine irrespective of its operating speed.

Some injection pumps are also provided with an emergency stop device, consisting of a lever which can instantly stop fuel supply, and therefore stop the engine.



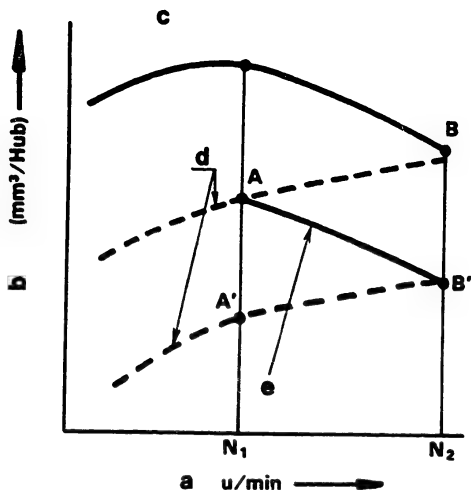


Fig. 13

- a = Engine speed (rpm)
- b = Fuel injection quantity per stroke ( $\text{mm}^3/\text{stroke}$ )
- c = Specific volume of intake air (weight)
- d = Fuel injection quantity
- e = Required fuel injection quantity

#### Torque control device

The torque control device maintains a certain ratio of injected fuel quantity per stroke to the volume of intake air (weight) to the engine. As the engine speed increases, the intake efficiency of the engine tends to deteriorate and causes the actual amount of air drawn into the engine to decrease.



## Torque control device (Continued)

Moreover, the fuel injection quantity generally increases as the engine speed increases, even if the position of the control rack is maintained. To compensate for the above tendency, a torque control device is provided. If the full-load fuel injection quantity is set to point A, where sufficient output power is obtained (as shown in Fig. 13), the fuel injection quantity will be excessive. As the engine speed increases, the result is incomplete combustion and smoke emission at point B. On the contrary, if the full-load fuel injection quantity is set to point B', where sufficient output power is obtained, the required output and torque will not be obtained at point A' due to a decrease in the fuel injection quantity.





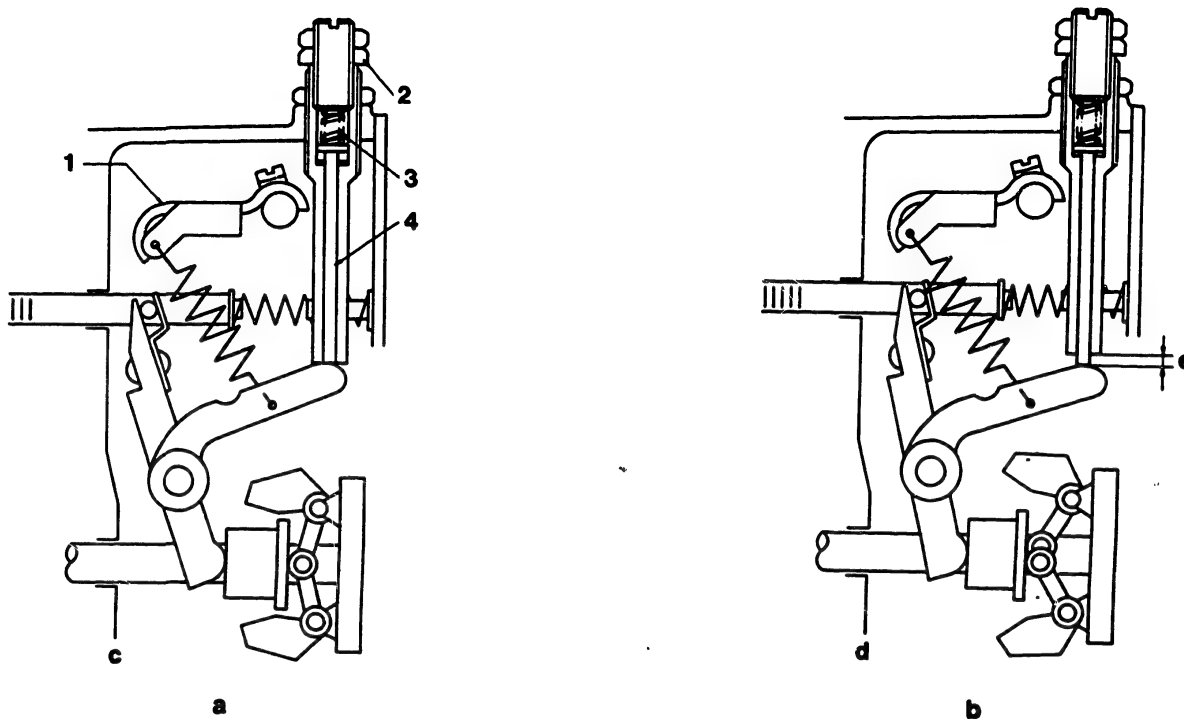


Fig. 14

1 = Swivel lever  
2 = Torque control device

3 = Torque control spring  
4 = Torque control rod

c = (Torque control stroke: 0)

d = (Torque control stroke: Maximum)  
e = Torque control stroke

**B5**

Governor Operation  
PES-K fuel injection pump



**B6**

Governor Operation  
PES-K fuel injection pump



## Torque control device (Continued)

When the engine speed increases further and exceeds  $N_1$  rpm (as shown in Fig. 13) where the sum of the centrifugal force and the torque control spring force balances the governor spring force, the torque control spring moves the tension lever with the aid of the torque control rod. This causes the control rack to move in the fuel-decrease direction until the torque control rod moves the tension lever to the predetermined torque control maximum stroke position. The torque control device will then cease to function (at an engine speed of  $N_2$  rpm as shown in Fig. 13).

When the engine speed exceeds  $N_2$  rpm, the centrifugal force remains smaller than the setting force of the governor spring. The control rack does not therefore move.

**B7**

Governor Operation

PES-K fuel injection pump



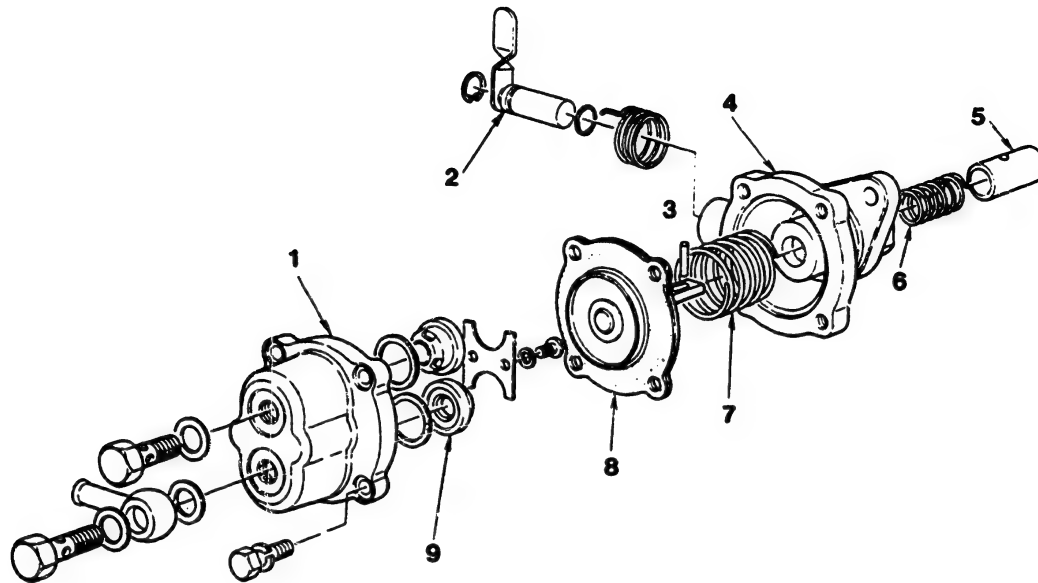


Fig. 15

**SUPPLY PUMP CONSTRUCTION**

- 1 = Cover
- 2 = Priming pump
- 3 = Pin
- 4 = Housing
- 5 = Tappet

- 6 = Tappet spring
- 7 = Spring
- 8 = Diaphragm
- 9 = Check valve

**B8**

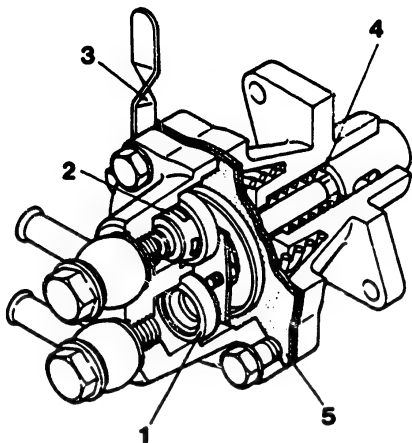
Supply Pump Construction  
PES-K fuel injection pump



**B9**

Supply Pump Construction  
PES-K fuel injection pump





**Fig. 16 Sectional view of the supply pump**

- 1 = Check valve (Suction)**
- 2 = Check valve (Supply)**
- 3 = Priming pump**
- 4 = Tappet spring**
- 5 = Diaphragm**

**Fig. 16 shows a sectional view of the supply pump. A diaphragm between the housing and cover, which is attached to the connecting rod, is under constant spring pressure towards the cover side. Provided in the connecting rod is an oblong slot, into which the tappet pin is inserted. The tappet is forced against the injection pump cam by the tappet spring.**



## Supply pump construction (Continued)

Two check valves (in opposing directions) are attached to the cover. The eye bolt at the lower part of the cover is connected by a pipe to the fuel tank. The eye bolt in the upper part of the cover is connected to the fuel filter by a pipe through which pressurized fuel is supplied to the filter. The priming lever on the side of the housing purges air from the fuel piping. The priming lever is not to be operated while the engine is running.

**B11**

Supply Pump Construction  
PES-K fuel injection pump



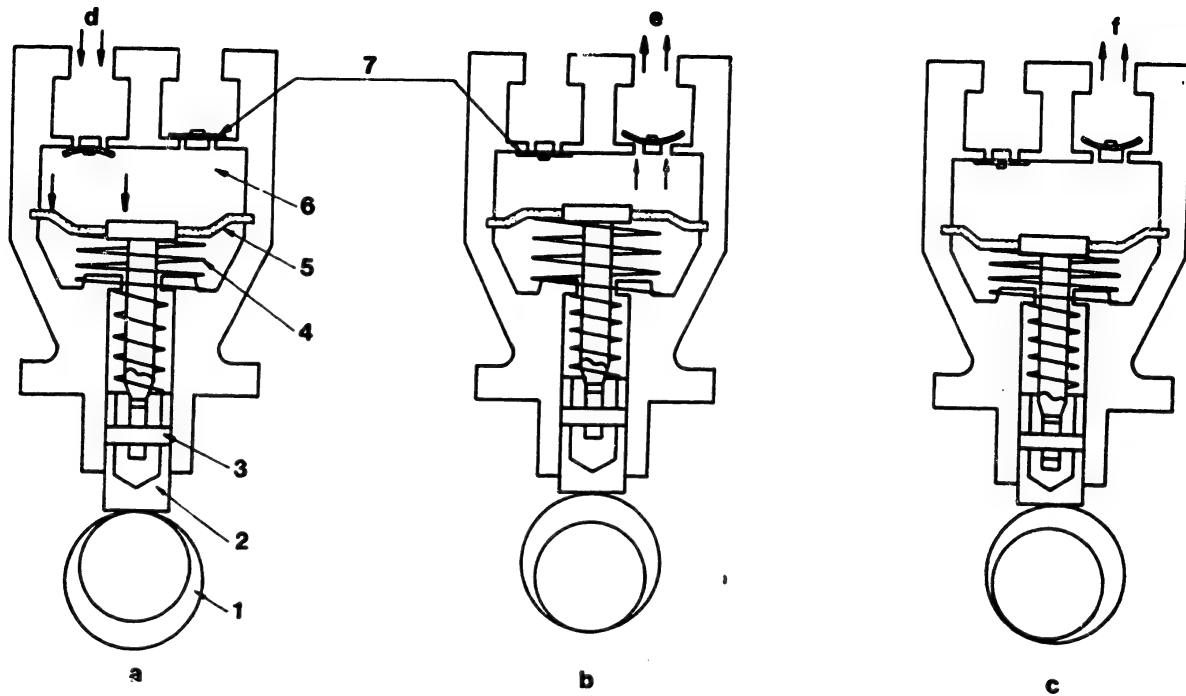


Fig. 17 a (Suction stroke)

b (Supply stroke)

c (At rest)

Supply pump operation

- 1 = Cam
- 2 = Tappet
- 3 = Pin
- 4 = Spring
- 5 = Diaphragm

- 6 = Chamber
- 7 = Check valves
- d = Suction port
- e = Supply port
- f = Supply port

Fig. 17 shows the method of operation of the supply pump



## Supply pump operation (Continued)

When the injection pump cam is in the bottom dead center position as shown in Fig. 17a, the diaphragm is pulled downwards by the tappet spring. This causes the pressure in the chamber to decrease. The check valve at the suction side is then opened and fuel is drawn into the chamber from the fuel tank. When the cam rotates to the top dead center position as shown in Fig. 17b, the tappet is pushed upwards. The fuel in the chamber is then pumped through the check valve at the supply side by the fuel filter. If the fuel quantity fed by the supply pump exceeds the fuel pump injection quantity, the fuel pressure at the supply side will exceed the diaphragm spring force. This will cause the diaphragm to remain at the bottom of the pump chamber as shown in Fig. 17c, with the tappet and pin moving only within the oblong slot in the diaphragm push rod, resulting in no fuel suction operation. When the fuel pressure at the supply side decreases following the above condition as shown in Fig. 17c, the diaphragm is again pushed upwards by the spring.



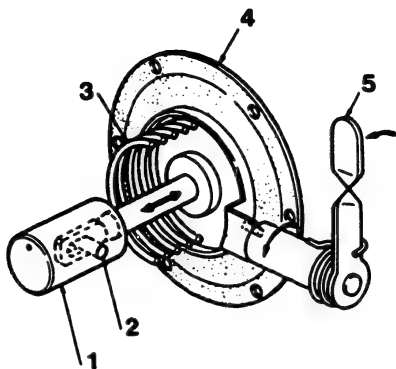


Fig. 18

- 1 = Tappet
- 2 = Pin
- 3 = Spring
- 4 = Diaphragm
- 5 = Priming lever

Fig. 18 shows the priming lever and related parts. The center part of the diaphragm can be moved by the priming lever, in a pumping action, to open the check valves at the suction and supply sides in order to supply fuel to the fuel filter.





SPECIAL TOOLS FOR DISASSEMBLY AND REASSEMBLY

Be sure to use the special tools shown in Fig. 19 and Table 1 when disassembling or reassembling the injection pump.

Table 1 Special tools for disassembly and reassembly

No.	Part no.	Tool name	Qty	Application
1	Comm. avail.	Socket wrench	1	Removing round nut
2	KDEP 2610	Roller tappet holder	3	Holding roller tappets
3	Comm. avail.	Wrench	1	Removing delivery valve holder
4	KDEP 2635	Extractor	1	Removing delivery valve
5	KDEP 2611	Clamping flange	1	
6	KDEP 2899	Plate	1	Installing camshaft
7	1 416 430 012	Coupling	1	Taper dia. 17 mm
8	KDEP 2890	Measuring device	1	Measuring camshaft end play
9	KDEP 2941	Roller tappet inserter	1	Installing roller tappet
10	KDAW 9989	Extractor	1	Ball bearing inner race on shafts dia. 12...30 mm
11	KDEP 2941	Roller tappet inserter	1	Holding roller tappets
12	KDEP 2919	Universal vice	1	Fixing pump
13	KDEP 2963	Bracket	1	Used together with univ. vice (KDEP 2919)
14	KDEP 2874	Guide	1	Oil seal installation
15	KDEP 2906	Spanner	1	Holding camshaft
16	KDEP 2915	Extractor	1	Installing plunger
17	KDEP 2918	Extractor	1	Removing flyweight and coupling
18	KDEP 2626	Wrench	1	Removing flyweight round nut
19	Comm. avail.	Ratchet handle	1	
20	Comm. avail.	Handle	1	

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Special Tools

PES-K fuel injection pump



**B17**

Special Tools

PES-K fuel injection pump



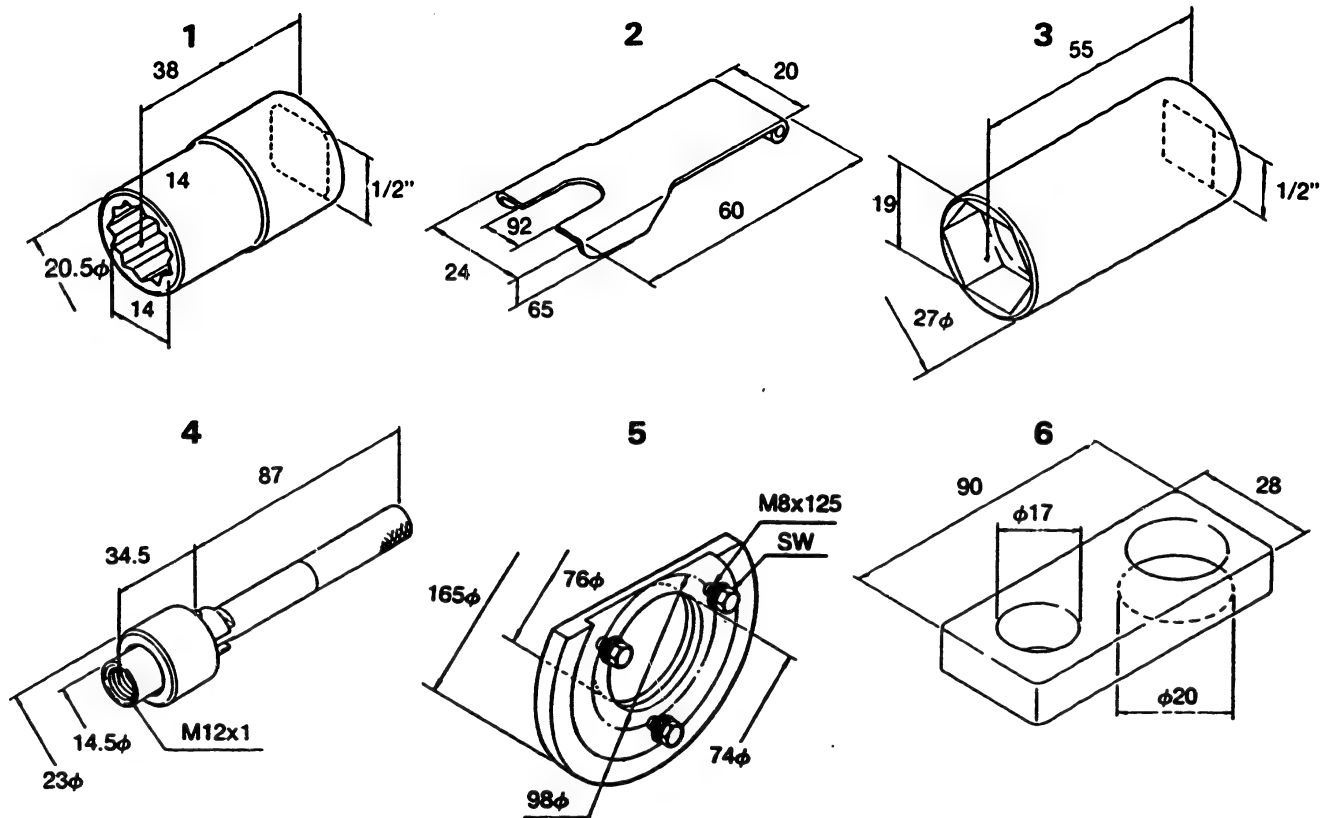


Fig. 19

Special tools for disassembly and reassembly

1 = Socket wrench  
4 = Extractor

2 = Roller tappet holder  
5 = Clamping flange

3 = Wrench  
6 = Plate

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Special Tools

PES-K fuel injection pump



B19

Special Tools

PES-K fuel injection pump



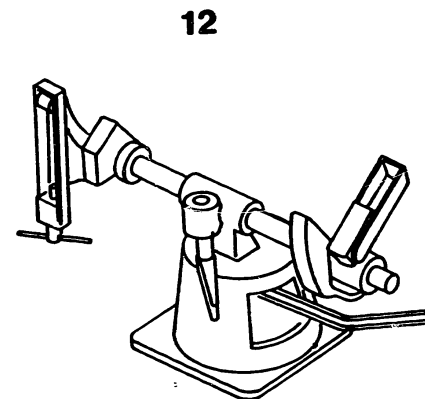
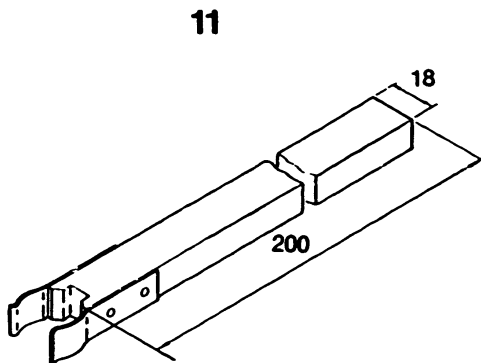
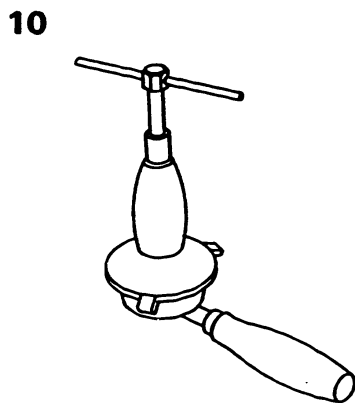
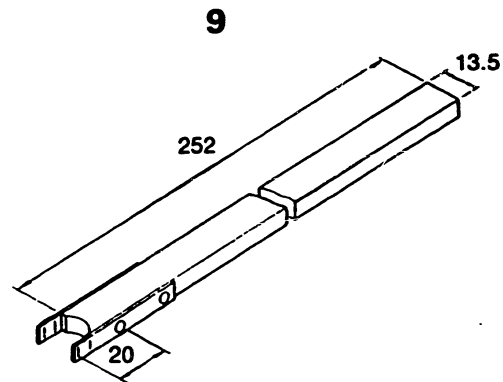
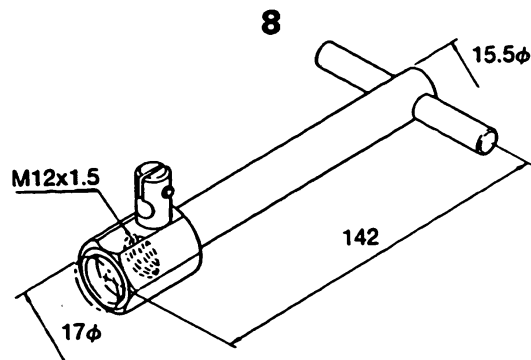
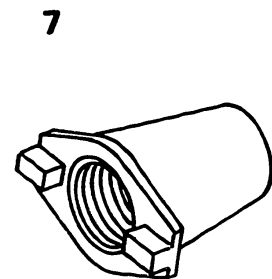


Fig. 19-1 Special tools for disassembly and reassembly

7 = Coupling  
10 = Extractor

8 = Measuring device  
11 = Roller tappet inserter

9 = Roller tappet inserter  
12 = Universal vice

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Special Tools

PES-K fuel injection pump



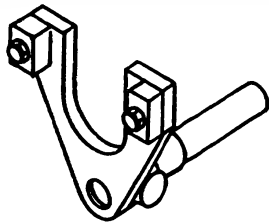
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Special Tools

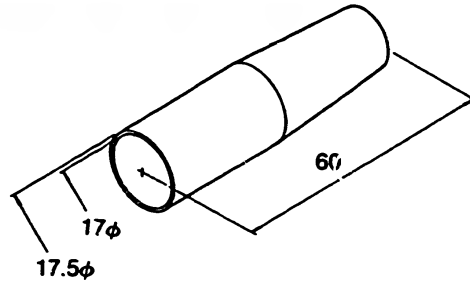
PES-K fuel injection pump



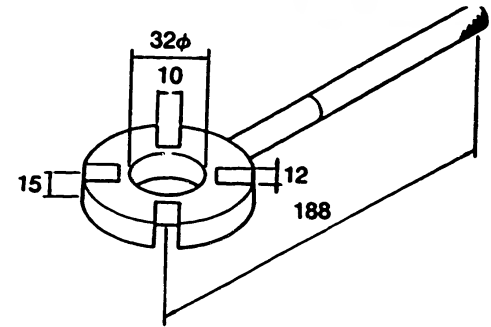
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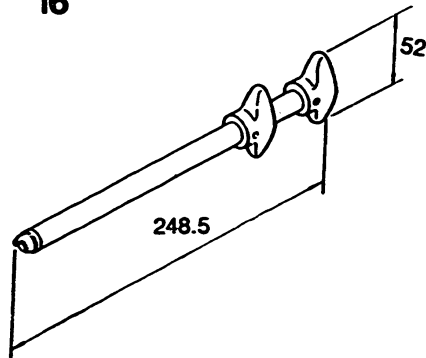
14



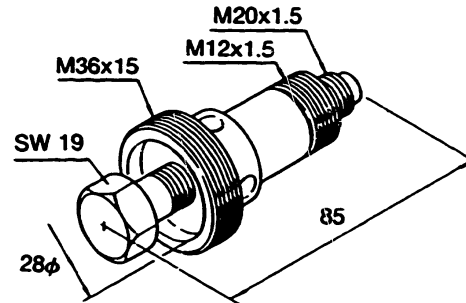
15



16



17



18

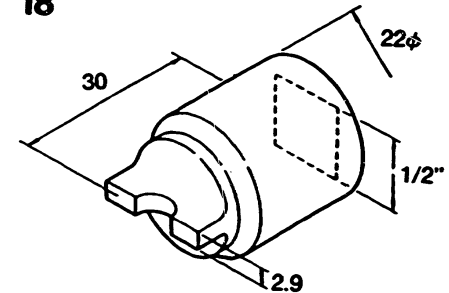


Fig. 19-2 Special tools for disassembly and reassembly

13 = Bracket

14 = Guide

15 = Spanner

16 = Extractor

17 = Extractor

18 = Wrench

B22

Special Tools

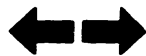
PES-K fuel injection pump

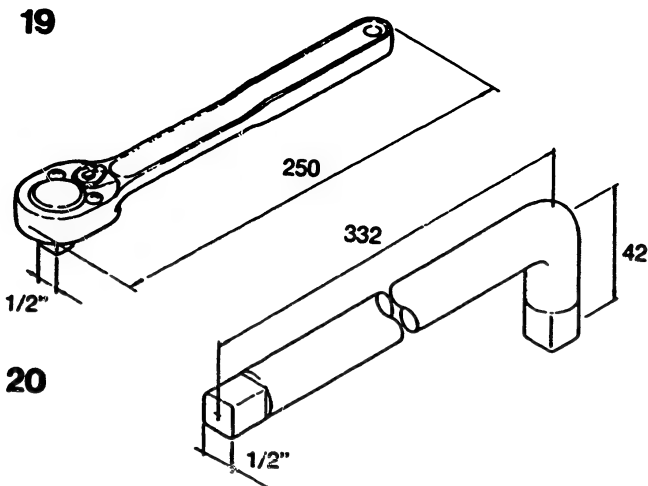


B23

Special Tools

PES-K fuel injection pump





**Fig. 19-3 Special tools for disassembly and reassembly**

**19 = Ratchet handle**

**20 = Handle**



## DISASSEMBLY

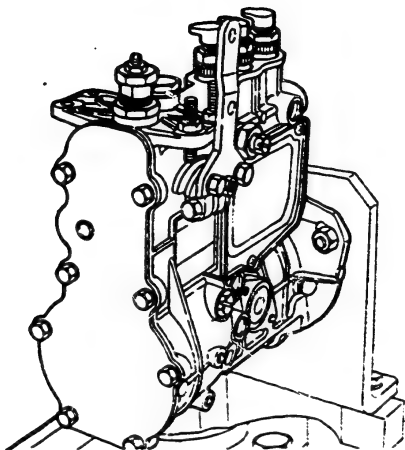
Observe the following precautions when disassembling the injection pump:

- Wash foreign matter and dirt off outside of injection pump.
- Measure and record the injection pump performance before disassembly.
- Arrange the removed parts in sequence on a work bench.

**B 25**

Disassembly  
PES-K fuel injection pump

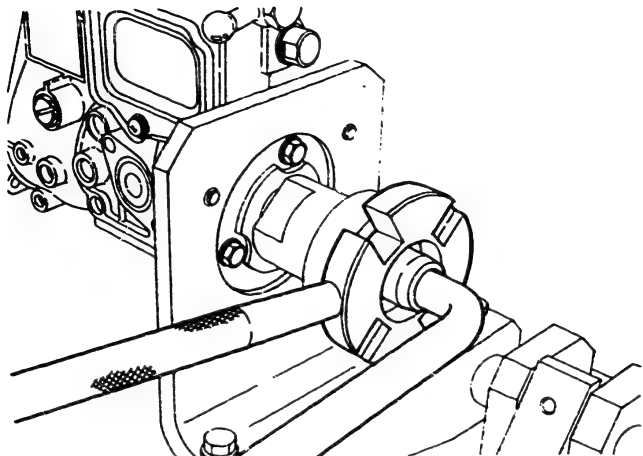




**Fig. 20 Attaching injection pump**

1. Attach the brackets (part no. KDEP 2963) to the universal vice (part no. KDEP 2919).
2. Attach the injection pump to the bracket.





**Fig. 21 Attaching coupling**

- 3. Attach coupling (part no. 1 416 430 012) to camshaft.**





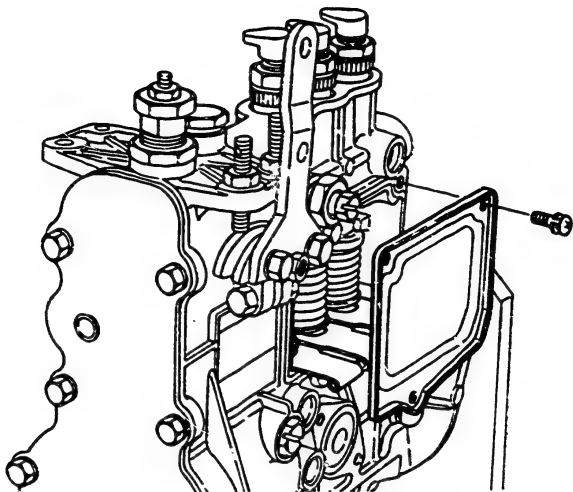


Fig. 22 Inserting tappet holder

4. Remove the three screws (item no. 3), then remove the cover (item no. 2) and gasket together. Rotate the camshaft until the roller tappets are positioned at top dead center. Insert the tappet holder between the tappet bolt (55/3) and nut (55/2).



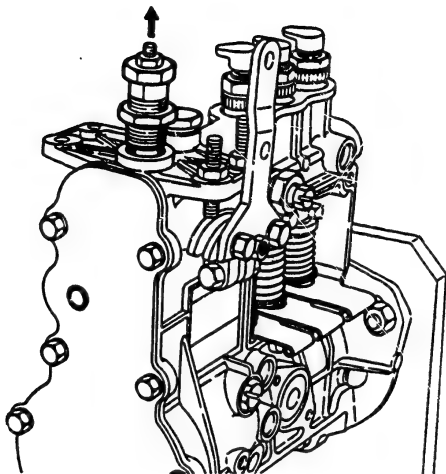


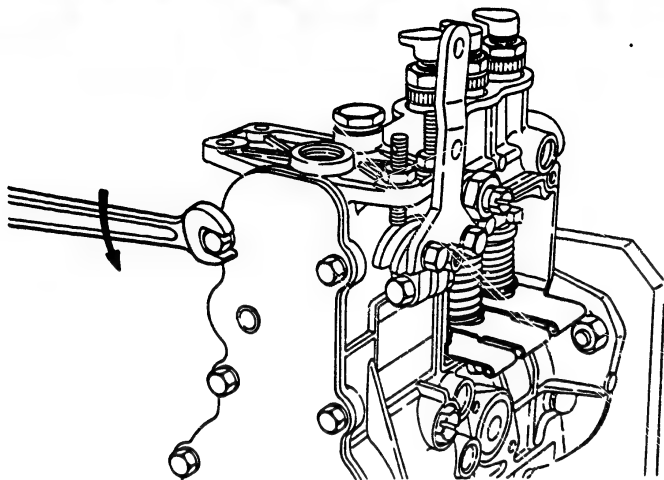
Fig. 23 Removing full-load stopper bolt

5. Loosen the nut (545), then remove the full-load stopper bolt (517).

**C1**

Disassembly  
PES-K fuel injection pump

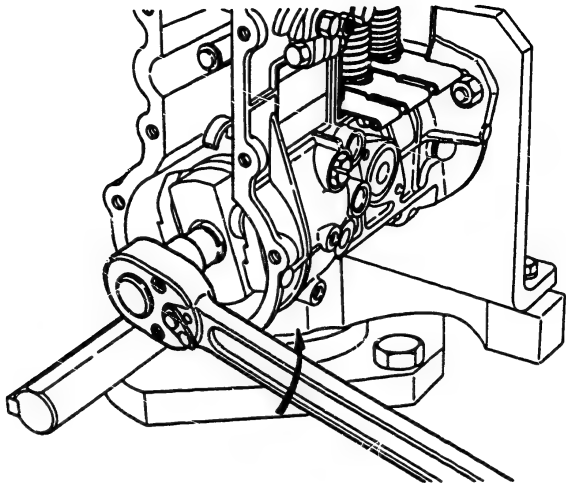




**Fig. 24 Removing cover**

- 6. Loosen the eight bolts (543 and 544) and remove cover (542).**
- 7. Remove the idling spring (575) and start spring (536).**





**Fig. 25 Removing round nut**

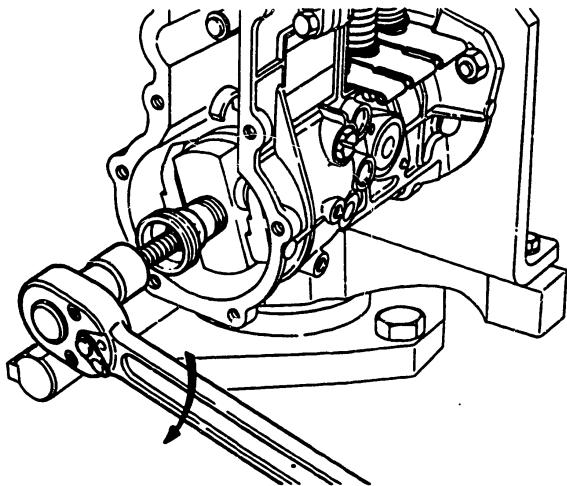
- 8. Remove the round nut (531) by holding the camshaft with the spanner (part no. KDEP 2906).**

**C3**

**Disassembly**

**PES-K fuel injection pump**

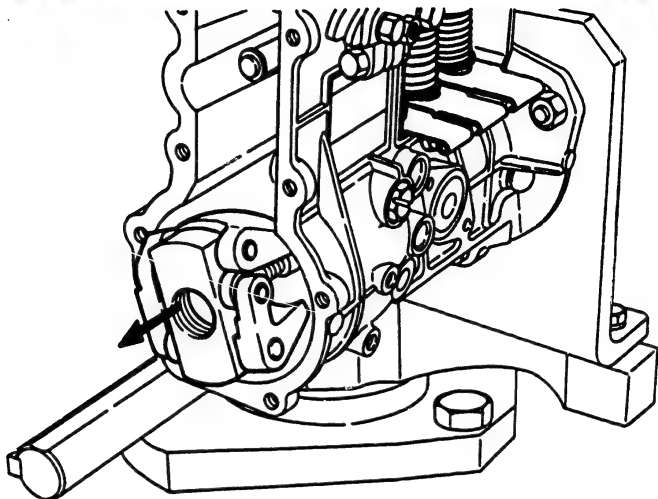




**Fig. 26 Attaching extractor**

9. Attach the extractor (part no. KDEP 2918) to the flyweight holder (528), then tighten the extractor bolt.

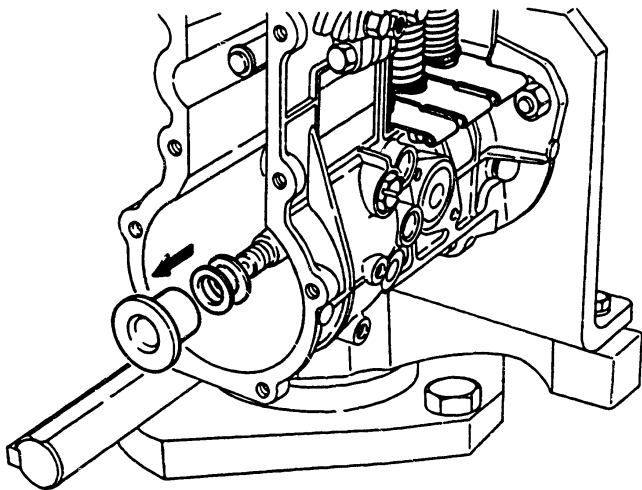




**Fig. 27 Removing flyweight holder**

**10. Remove flyweight holder from camshaft.**

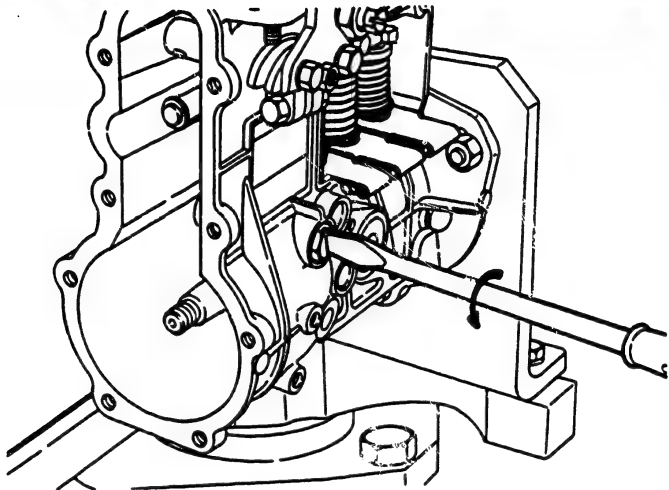




**Fig. 28 Removing sleeves and shim**

**11. Remove the sleeve (524) and shim (523).**



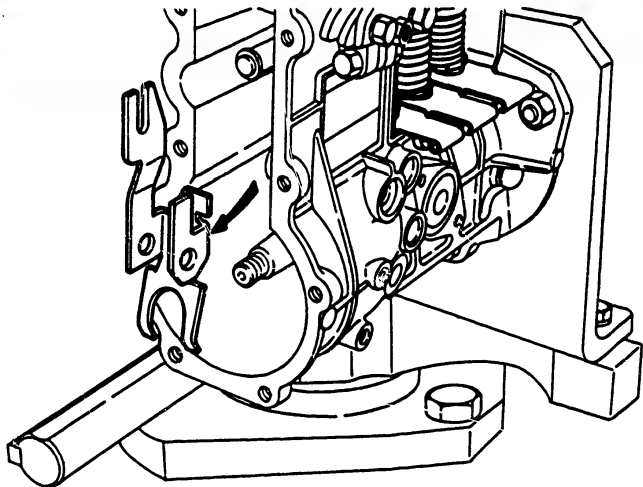


**Fig. 29 Removing plugs**

12. Remove the two plugs (522).
13. Remove the pin (520).



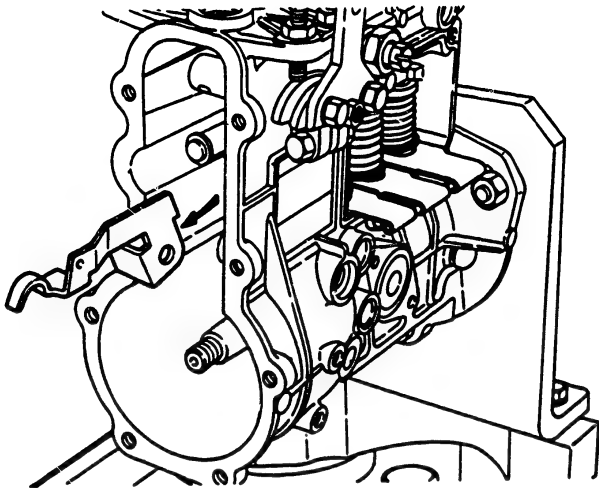




**Fig. 30 Removing guide lever**

14. Remove the guide lever (518) and spacer (519).





**Fig. 31 Removing tension lever**

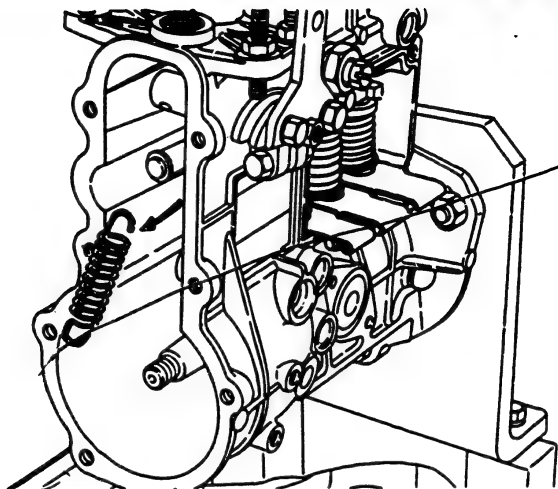
**15. Remove the tension lever (516).**

**C9**

**Disassembly**

**PES-K fuel injection pump**





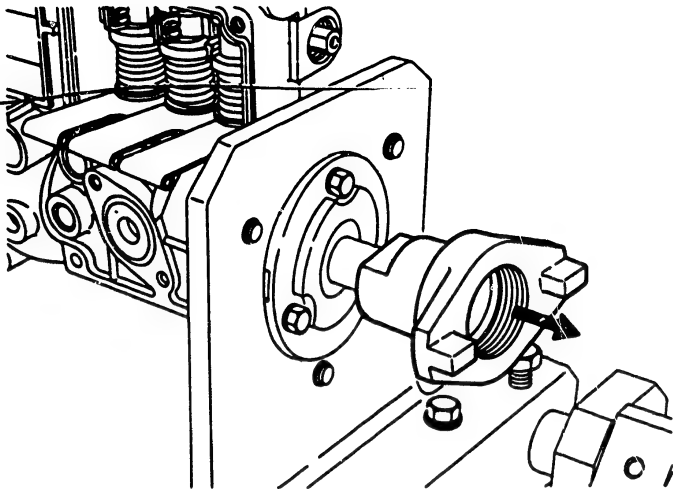
**Fig. 32 Removing governor spring**

16. Remove the governor spring (514) from the swivel lever (510).
17. Remove the rack cap (165).

**C10**

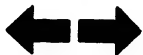
Disassembly  
PES-K fuel injection pump

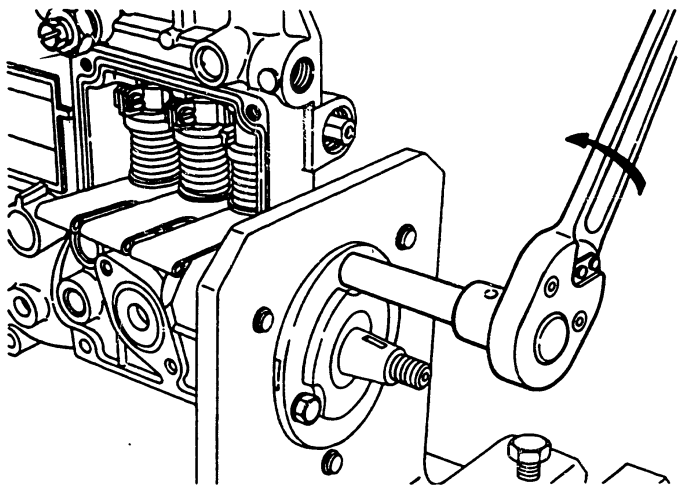




**Fig. 33 Removing coupling**

- 18. Remove the coupling using the extractor (part no. KDEP 2918).**

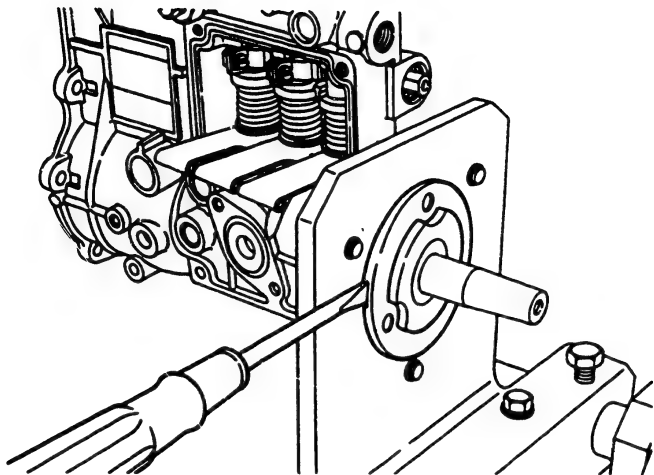




**Fig. 34 Removing bolts**

19. Remove the three bolts (104) which secure the bearing cover (101).

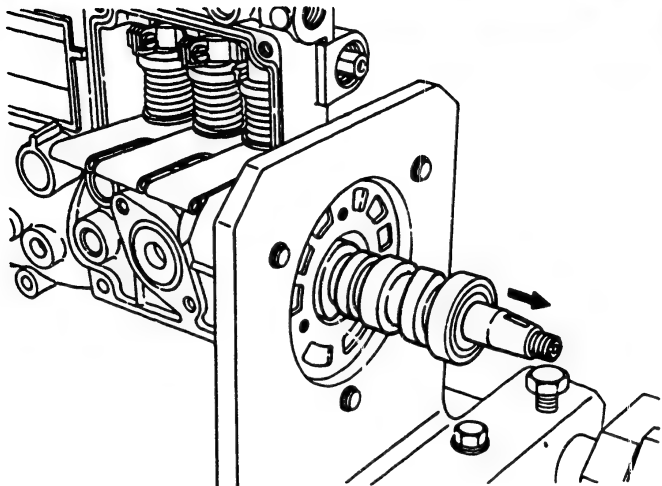




**Fig. 35 Removing bearing cover**

20. Attach the guide (part no. KDEP 2874) to the end of the camshaft, then remove the bearing cover using a screwdriver.

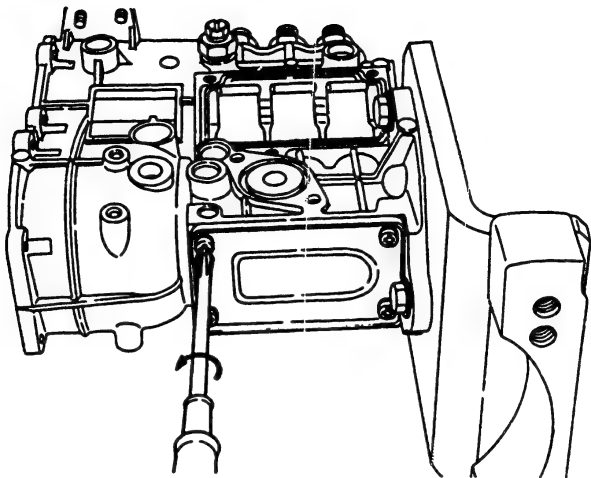




**Fig. 36 Removing camshaft**

21. Remove the camshaft from the drive side.
22. Rotate the injection pump through 90°.



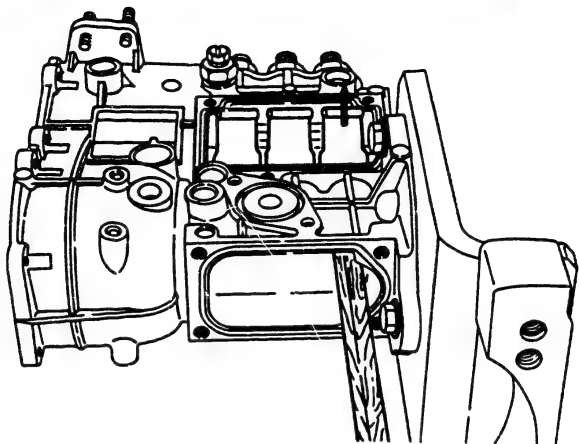


**Fig. 37 Removing bolts**

23. Loosen the four screws (25), then remove the bottom cover (16) and gasket (24) together.





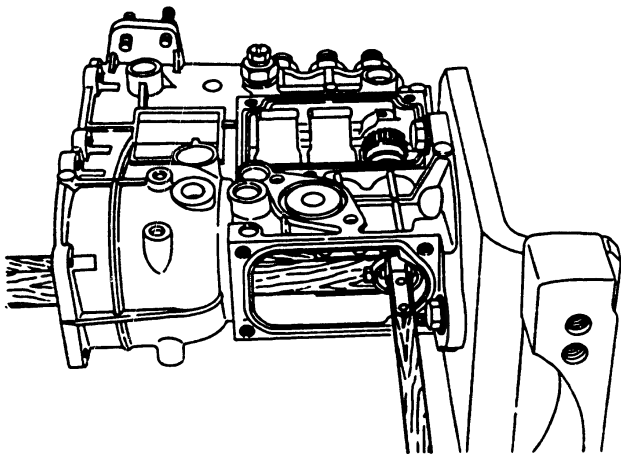


**Fig. 38 Removing tappet holder**

- 24. Insert the roller tappet inserter (part no. KDEP 2941) from the bottom of the injection pump to hold the roller tappet.**

**Push the roller tappet inserter to compress the plunger spring, then remove the tappet holder.**

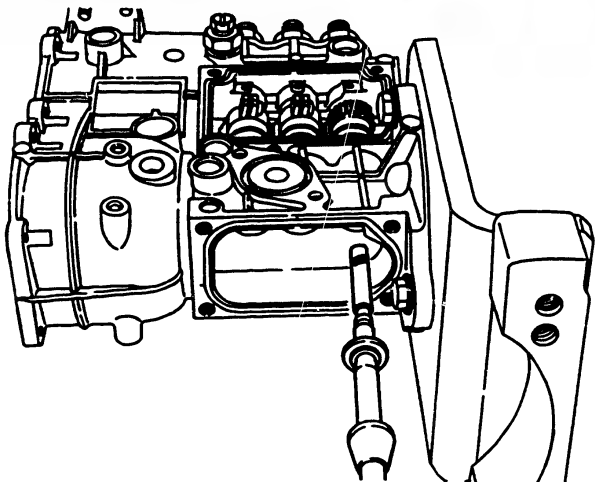




**Fig. 39 Removing roller tappet**

25. Insert the roller tappet inserter (part no. KDEP 2941) into the cam chamber from the governor side to hold the tappet body. Remove the roller tappet inserter which holds the roller tappet. Then remove the roller tappet assembly.



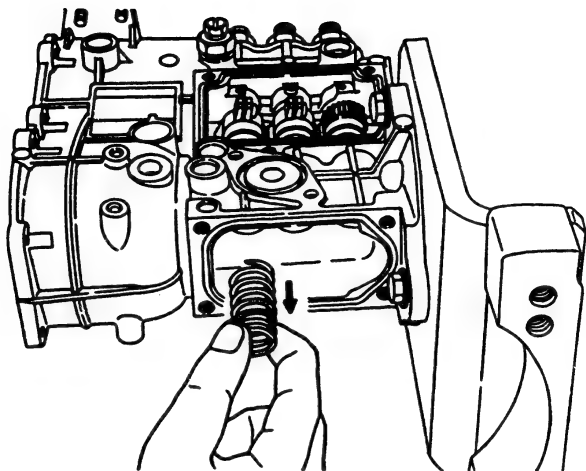


**Fig. 40** Removing plungers

26. Hold the lower part of the plunger (30) with the extractor (part no. KDEP 2915), then remove the lower spring seat (63) and plunger together.

**Caution:** Be careful not to let the plungers make contact with other parts when removing. Put them in clean light oil in their order of removal.





**Fig. 41 Removing plunger springs**

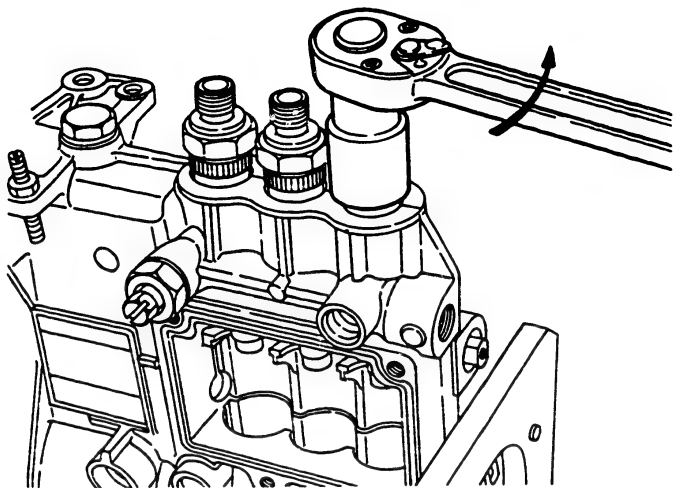
27. Remove the plunger spring (61) and upper spring seat (62).
28. Remove control sleeve.
  - 1) Before removing the control sleeve from cylinder no. 1 (which is fully toothed), move the control rack so that the slot in the control sleeve faces vertically upwards.
  - 2) Measure distance between end of control rack and drive side end face of pump housing. Remove control sleeve for cylinder no. 1.



**Note:** This procedure is important so as to ensure that prescribed delivery is obtained with cylinder no. 1, since the control sleeve of cylinder no. 1 and its tothing are in one piece. They thus differ from the others and do not permit adjustment of the injection quantity.

- 3) Remove the control sleeves of the other cylinders.

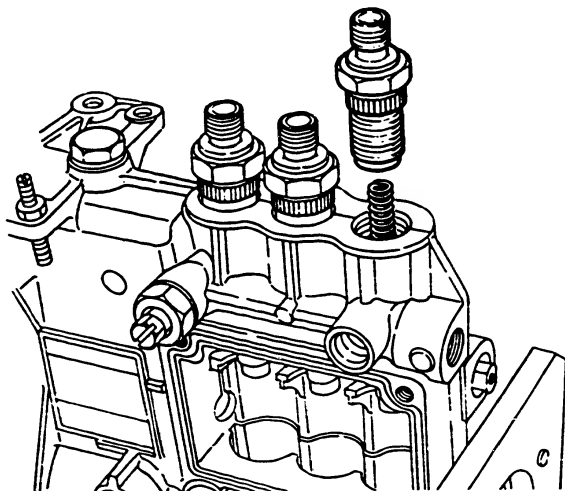




**Fig. 42** Loosening delivery valve holder

29. Set the injection pump upright, then loosen the delivery valve holder (41) using a wrench (commercially available).

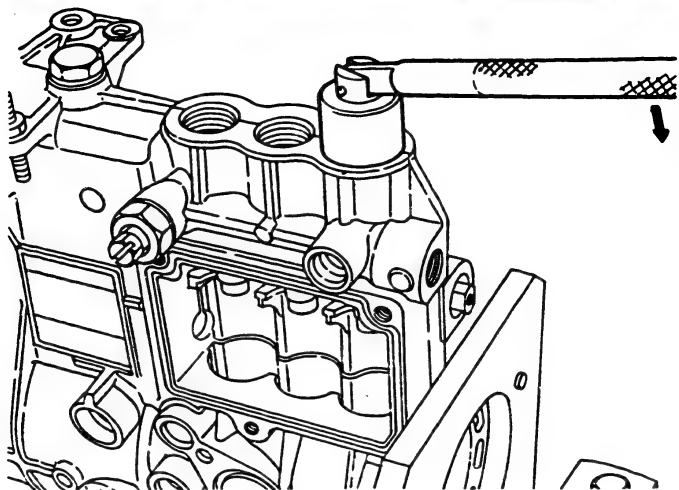




**Fig. 43** Removing delivery valve holder

30. Remove the delivery valve holder (41), being careful not to lose the delivery valve spring (37).



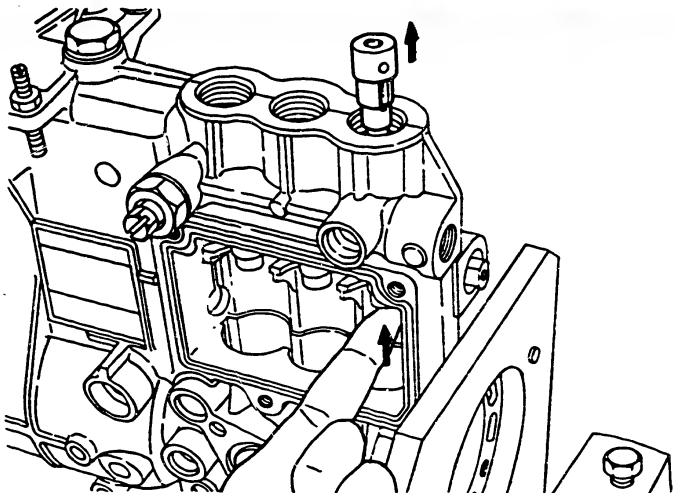


**Fig. 44 Removing delivery valves**

31. Screw the extractor (part no. KDEP 2635) into the delivery valve (36). Push the lever down and remove the delivery valve.  
Put the delivery valves in clean light oil in their order of removal in the same way as for the plungers.





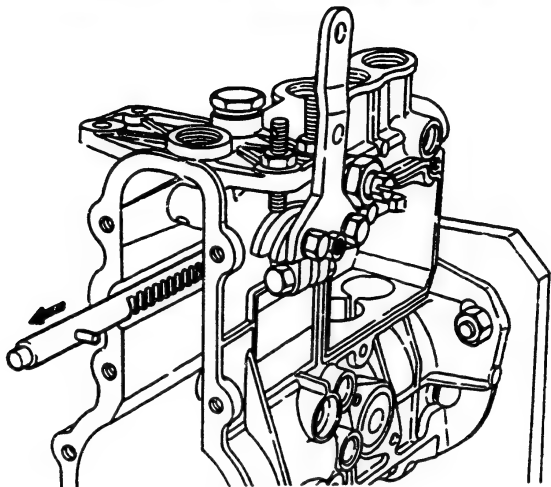


**Fig. 45 Removing plunger barrels**

32. Push the plunger barrels by hand to remove. Attach them to their corresponding plungers and place in light oil.

**Caution:** Be sure to keep each plunger with its corresponding plunger barrel. If the plungers and barrels are not matched, the clearances between them may not meet the standard value.





**Fig. 46 Removing control rack**

33. Remove the guide screw (68), then remove the control rack (67) from the governor side.



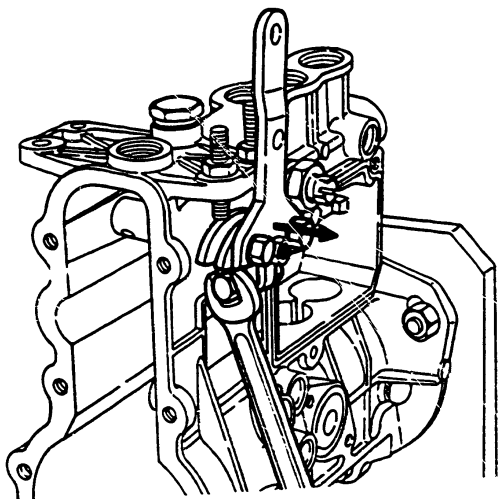
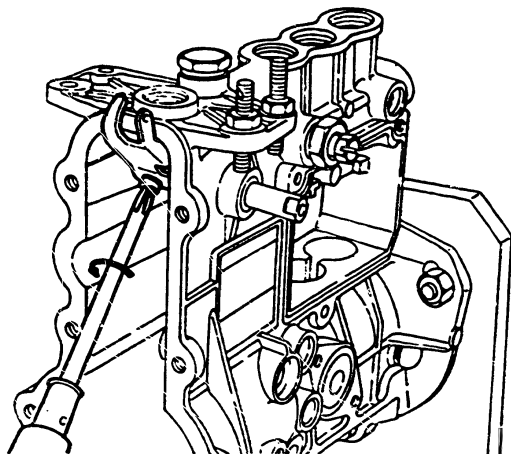


Fig. 47 Removing control lever

34. Loosen the bolt, then remove the control lever assembly (501) from the governor shaft (503).

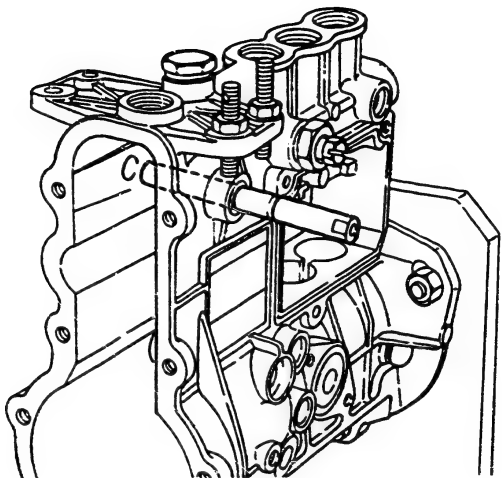




**Fig. 48 Removing swivel lever**

35. Loosen the two screws (506) and remove the swivel lever (501).

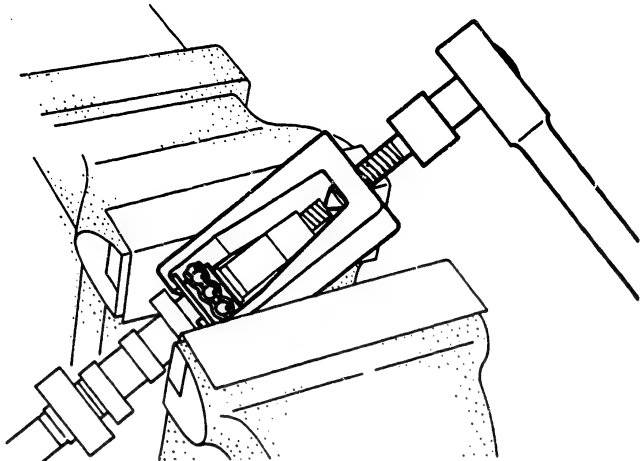




**Fig. 49 Removing governor shaft**

36. Remove the governor shaft from the pump housing.





**Fig. 50 Removing bearing inner race**

37. When replacing the bearings or when adjusting the thrust gap of the camshaft, remove the inner races of the bearings (91 and 91A) from the camshaft using extractors.

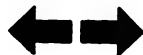
Disassembly of the injection pump is completed with the above operations.

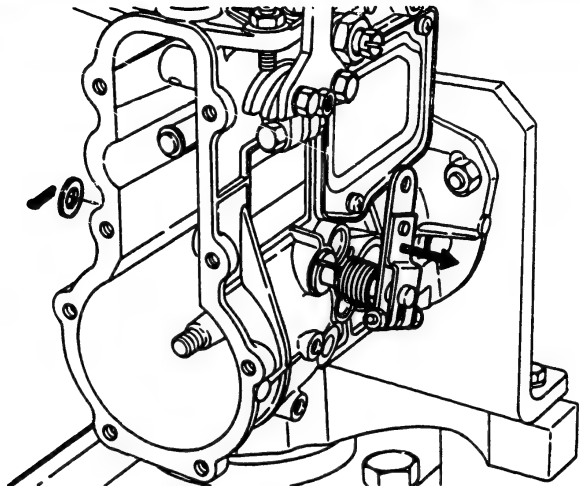
The accessories should be disassembled as necessary in the following manner.

**D1**

**Disassembly**

**PES-K fuel injection pump**





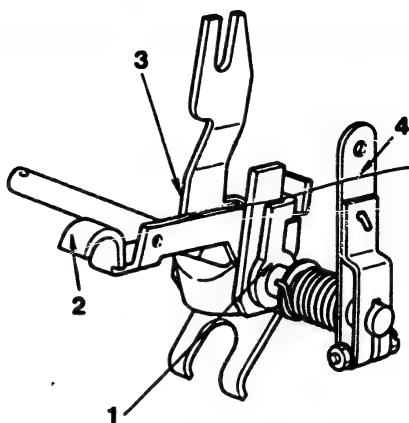
**Fig. 51 Removing stop lever**

### **Disassembly of accessories**

#### **Stop lever**

- 1. Remove the split pin and washer.**
- 2. Remove the hook of the return spring from the pump housing.**
- 3. Remove the stop lever together with the shaft from the pump housing.**





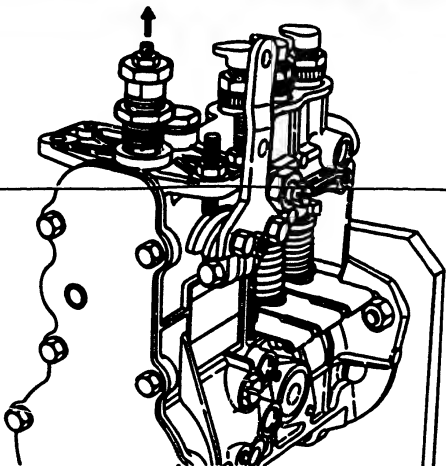
**Fig. 52 Stop lever and related parts**

- 1 = Stopping arm**
- 2 = Arm**
- 3 = Guide lever**
- 4 = Stop lever**

**4. Fig. 52 shows the stop lever and related parts.**







**Fig. 53 Removing torque control device**

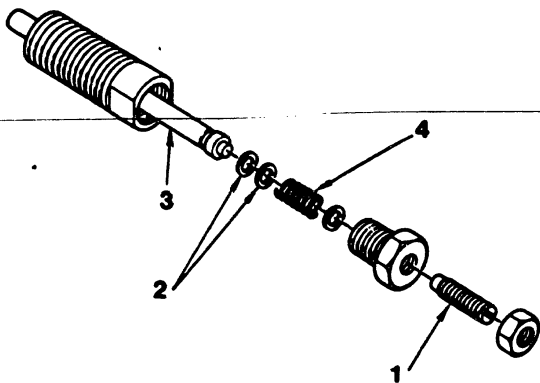
**Torque control device**

1. The torque control device is mounted on the pump housing with the full-load stopper bolt.
2. Loosen the nut (545), then remove the torque control device.

**D4**

**Disassembly**  
**PES-K fuel injection pump**



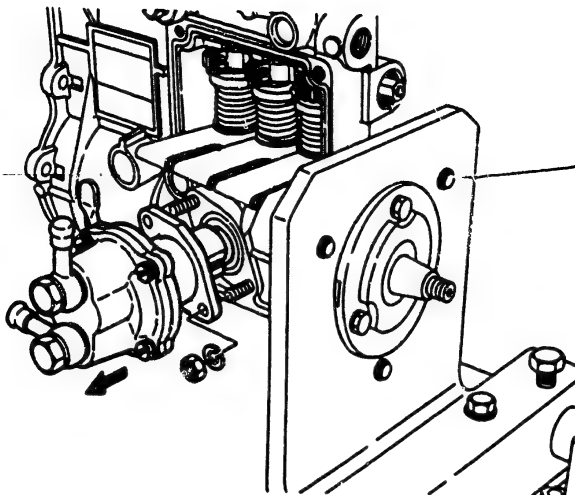


**Fig. 54 Components of torque control device**

- 1 = Adjusting bolt**
- 2 = Adjusting shim**
- 3 = Torque control rod**
- 4 = Torque control spring**

**3. Fig. 54 shows the components of the torque control device.**





**Fig. 55 Removing supply pump**

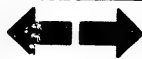
**Supply pump**

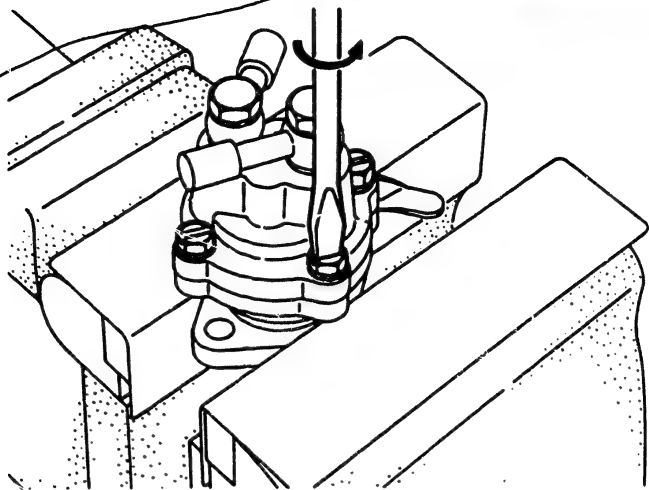
- 1. Loosen the two nuts, then remove the supply pump from the injection pump.**

**D6**

**Disassembly**

**PES-K fuel injection pump**





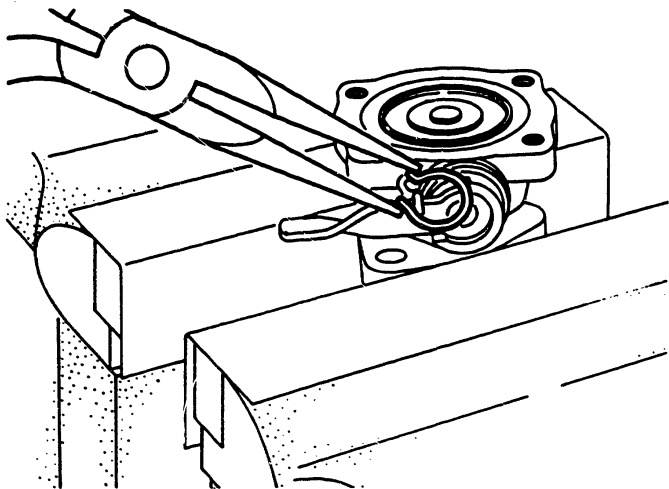
**Fig. 56 Removing bolts**

2. Hold the supply pump in a vice and loosen the four bolts which secure the cover.

**Caution:** Use vice jaw covers to avoid damaging pump housing.

3. Remove the cover.

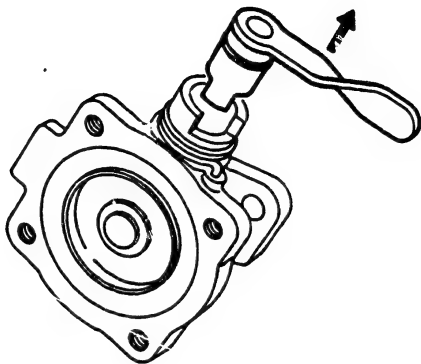




**Fig. 57 Removing snap ring**

- 4. Remove the snap ring from the priming lever.**





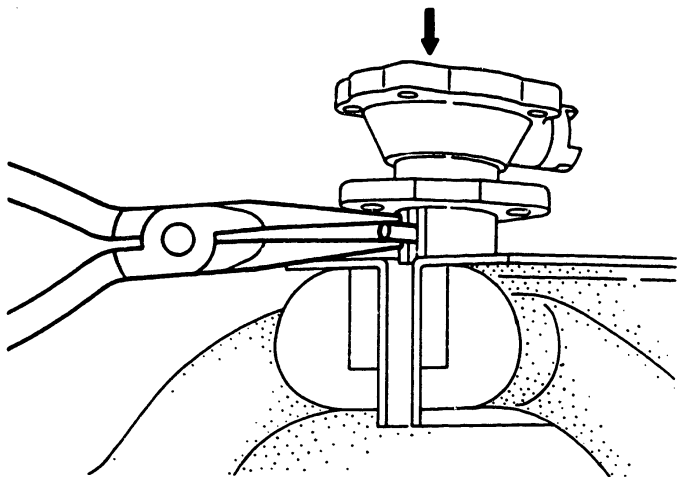
**Fig. 58 Removing lever assembly**

**5. Remove the lever assembly.**

**D9**

**Disassembly**  
**PES-K fuel injection pump**

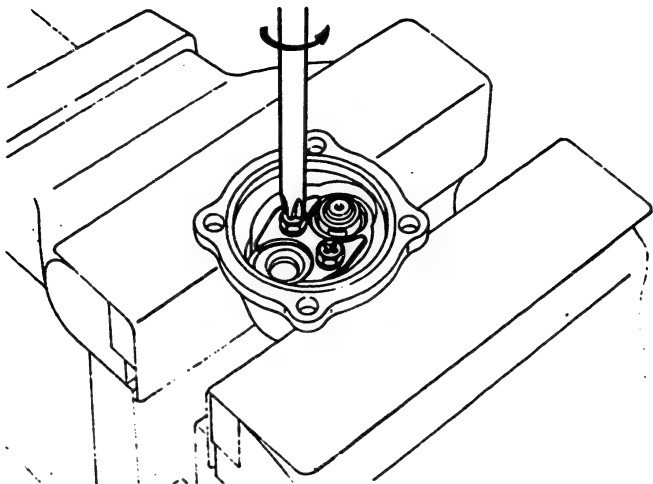




**Fig. 59 Removing pin**

6. Push the diaphragm towards the tappet and rotate the tappet to remove the pin. The tappet can be rotated up to 90°.
7. After the pin has been removed, all of the components in the cam housing can be disassembled.



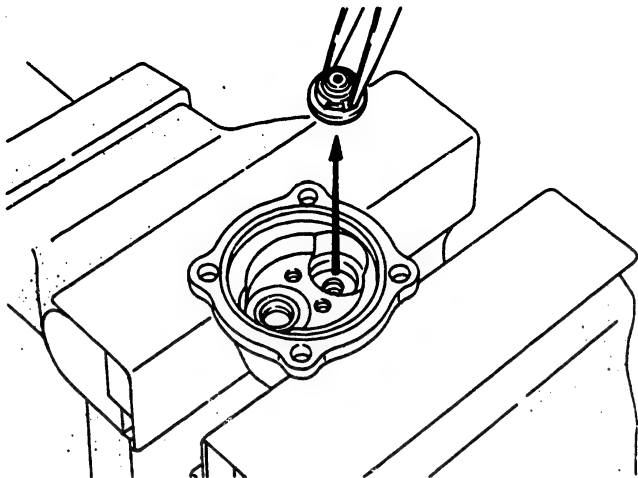


**Fig. 60 Removing bolts**

8. Hold the cover with a vice, then loosen the two bolts which secure the retainer.







**Fig. 61 Removing check valves**

**9. Remove the two check valves.**



## INSPECTION

### Pump housing

If cracks, wear or damaged threads are found in the pump housing, repair or replace the pump housing.

### Camshaft and bearings

1. If the cam surface of the camshaft is worn or damaged, or the key seat in the camshaft is deformed, or the threaded areas at both ends are damaged, replace the camshaft.
2. If a bearing is damaged in such a way that balls come out at the races, or the surface of the ball has peeled or lost its luster, it must be replaced.

### Roller tappet

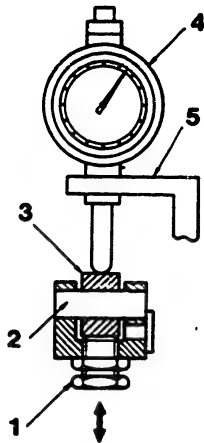
1. Measure the clearance between the roller and roller pin by moving the adjusting bolt up and down as shown in Fig. 62. If the clearance exceeds 0.2 mm, replace the roller and roller pin.
2. If the roller is damaged, worn or its surface has peeled, replace it.

**D13**

Inspection

PES-K fuel injection pump





**Fig. 62 Measuring clearance between roller and roller pin**

- 1 = Adjusting bolt**
- 2 = Roller pin**
- 3 = Roller**
- 4 = Dial gauge**
- 5 = Magnet stand**



## Roller tappet (Continued)

3. Measure the clearance between the roller tappet and the roller tappet hole in the pump housing. If the clearance exceeds the value shown in Table 2, the corresponding roller tappet must be replaced.

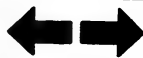
Table 2

Item	Assembly standard	Limit
Clearance between roller tappet and roller tappet hole in pump housing	0.03 - 0.07 mm	0.2 mm

**D15**

Inspection

PES-K fuel injection pump



## Control rack and control sleeves

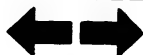
1. If the control rack is bent or its teeth are worn, repair or replace it.
2. If the play between the control rack and the control sleeves exceeds the value shown in Table 3, replace them.

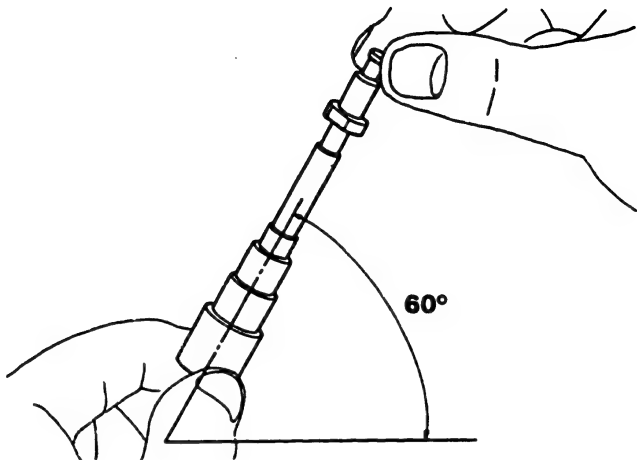
Table 3

Item	Assembly standard	limit
Play between control rack & control sleeve	0.15 mm	0.3 mm

## Plunger

1. Clean plungers and plunger barrels with light oil. Check that the plunger helix is not damaged, that the colour of the plungers and plunger barrels has not changed, and that the plungers move smoothly in the plunger barrels. If there are problems, replace plunger assemblies.

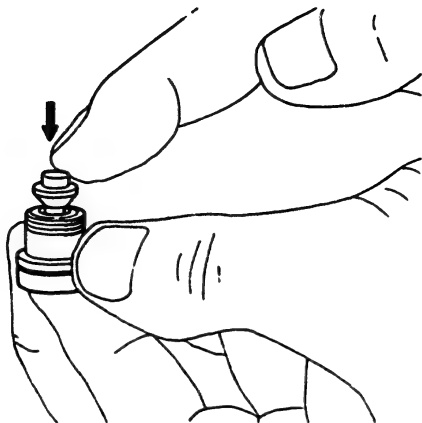




**Fig. 63 Plunger slide test**

2. After cleaning the plunger assembly with light oil, make sure that the plunger slides smoothly into the plunger barrel under its own weight, when the plunger assembly is inclined at  $60^\circ$  as shown in Fig. 63. Change the plunger position by rotating it, and check the plunger movement several times in the above manner. If a plunger slides into the plunger barrel too quickly or does not slide smoothly, replace the plunger assembly.



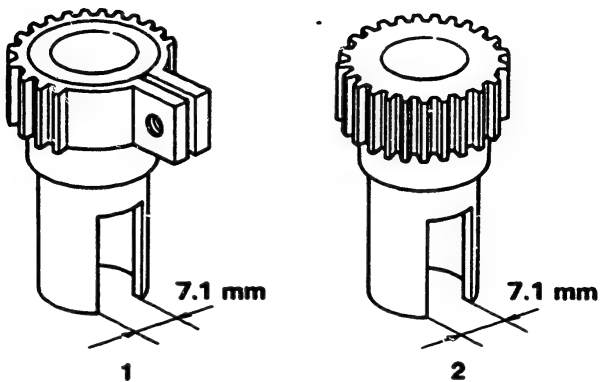


**Fig. 64 Checking piston for wear**

**Delivery valve assembly**

1. If the piston or seat of the delivery valve is damaged or worn, replace the delivery valve assembly.
2. After cleaning the delivery valve assembly with light oil, close the lower part of the delivery valve seat with a finger, and gently push the delivery valve. Make sure that the delivery valve returns when it is released. If the piston is worn excessively, the delivery valve will not return when released. If it is not returned, replace the delivery valve assembly.





**Fig. 65 Measuring groove width  
in control sleeve**

- 1 = Other cylinders**
- 2 = Cylinder no. 1**

#### **Control sleeve**

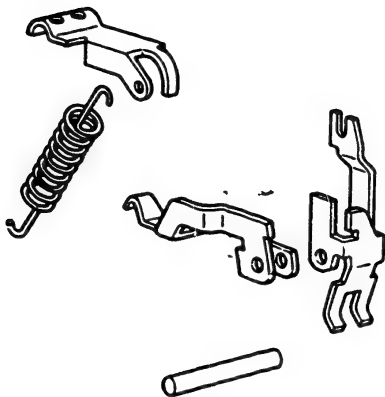
Measure the width of the groove in the control sleeve. If the width exceeds 7.1 mm, replace the control sleeve.

#### **Governor levers**

If the lever is bent or any pin holes are worn excessively, replace the lever.







**Fig. 66 Levers, pin and springs**

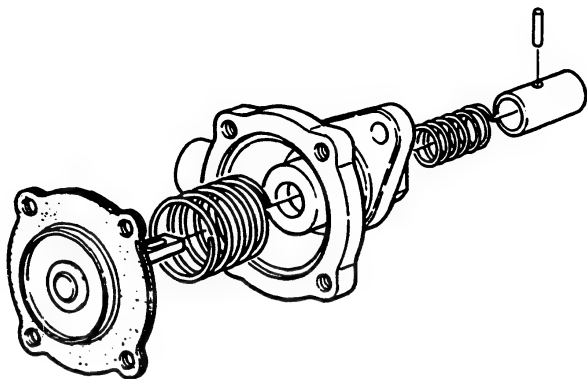
**Springs**

If a spring has rusted, is bent, or deformed due to fatigue, replace it.

**Screw threads**

If any threaded parts are damaged, repair or replace them.





**Fig. 67 Diaphragm, springs, housing and tappet**

**Supply pump**

**1. Diaphragm**

If the diaphragm is damaged or the connecting rod is loose, the parts must be replaced.

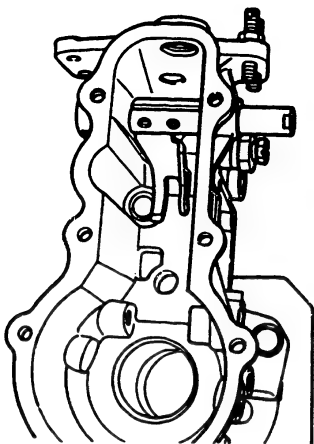




**Fig. 68 Check valves and cover**

- 2. Check valves**  
As the check valves are expendable, replace them with new ones when they are removed.
- 3. Other parts**  
If any other parts have rusted, or are excessively worn or damaged, replace them.





**Fig. 69 Attaching swivel lever and shaft**

**REASSEMBLY**

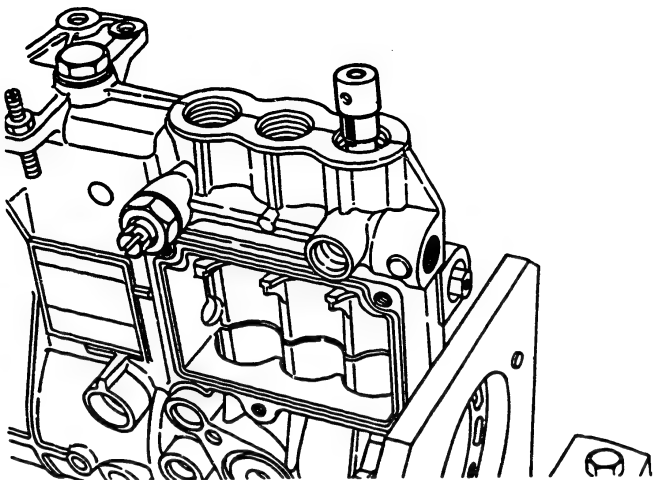
Reassemble the injection pump by reversing the disassembly procedures.

Observe the following precautions during reassembly:

**Injection pump**

1. First attach the shaft and swivel lever to the housing.

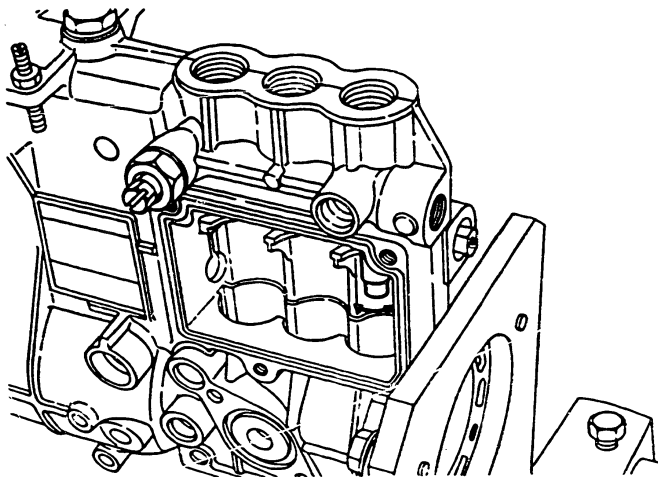




**Fig. 70** Installing plunger barrels

2. Install the plunger barrels so that the locating pins in the pump housing make correct contact with the grooves in the plunger barrels.





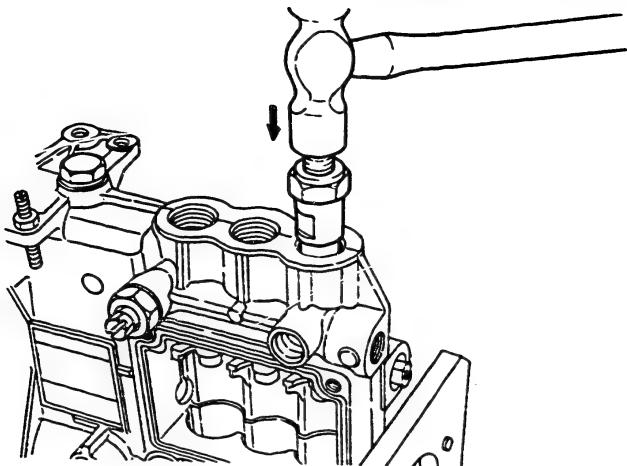
**Fig. 71 Assembled plunger barrels**

3. After installing the plunger barrels, make sure that they cannot be rotated manually.

**Note:** If the locating pin does not correctly contact the groove in the plunger barrel, the plunger barrel can be rotated by hand.

4. Put the delivery valve, with a new gasket, on the plunger barrel.





**Fig. 72 Attaching gasket**

5. Gently tap the extractor  
(part no. KDEP 2635) to secure the  
gasket against the delivery valve seat.

**Note:** When the gasket is securely in contact with the delivery valve seat, the sound generated by tapping the extractor changes. Do not tap the extractor after the gasket is touching the delivery valve seat.



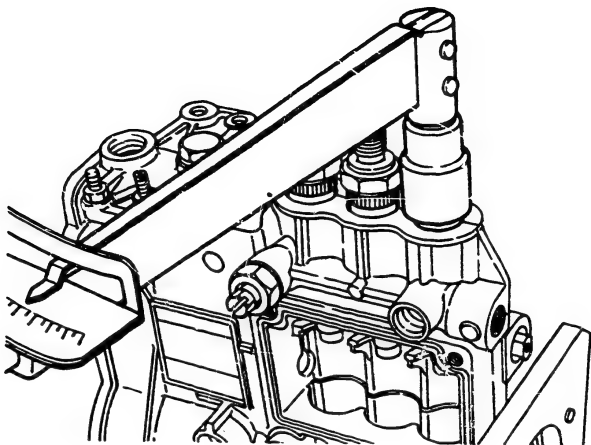


Fig. 73 Tightening delivery valve holder

- Put the spring on the delivery valve, then attach the delivery valve holder. Be sure to secure the delivery valve holder to the specified torque using a torque wrench in accordance with the following procedures:  
Tightening procedures: Tighten with 3 kg-m - loosen to 0 kg-m - tighten with 3 kg-m - loosen to 0 kg-m - tighten with 3.5 kg-m. To ensure that the gasket functions effectively, make sure that the delivery valve holder is secured following the three steps outlined above.





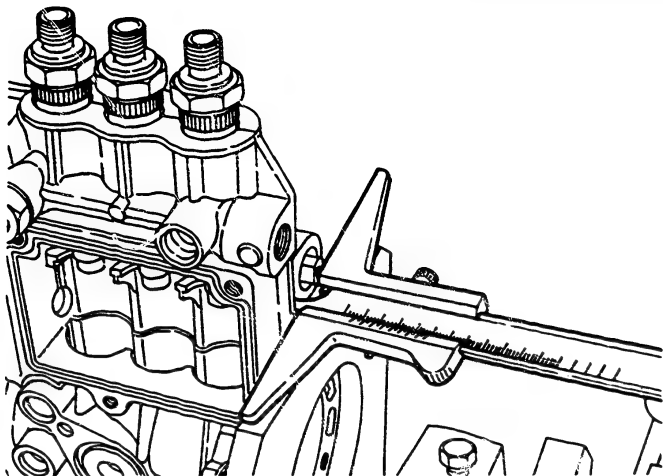


Fig. 74 Positioning control rack

7. Insert the control rack into the pump housing from the governor side. Make sure that the control rack moves easily.
8. Control sleeve installation.
  - 1) Place the control rack in the position measured in Step 28 of DISASSEMBLY "Removing control sleeve".
  - 2) Turn injection pump through 90°.



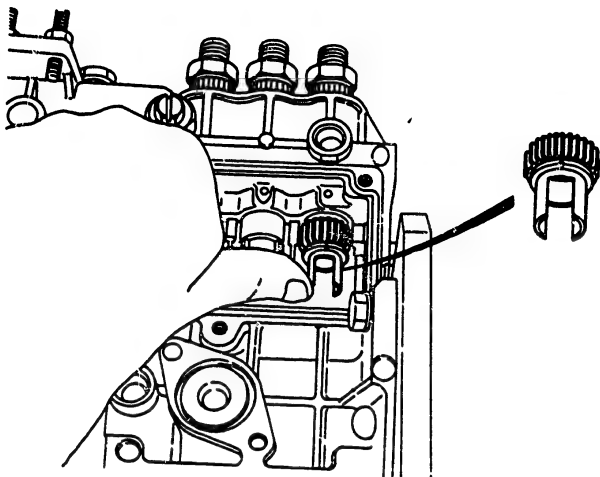


Fig. 75 Installing control sleeve for No. 1 cylinder

- 3) Engage the No. 1 cylinder control sleeve with the control rack with the groove facing vertically upwards as shown in Fig. 75.
- 4) Position the control rack so that it protrudes approx. 3.5 mm out of the drive side end face of the pump housing.
- 5) Install the control sleeves of the other cylinders (with the exception of No. 1 cylinder) such that the grooves face vertically upwards.



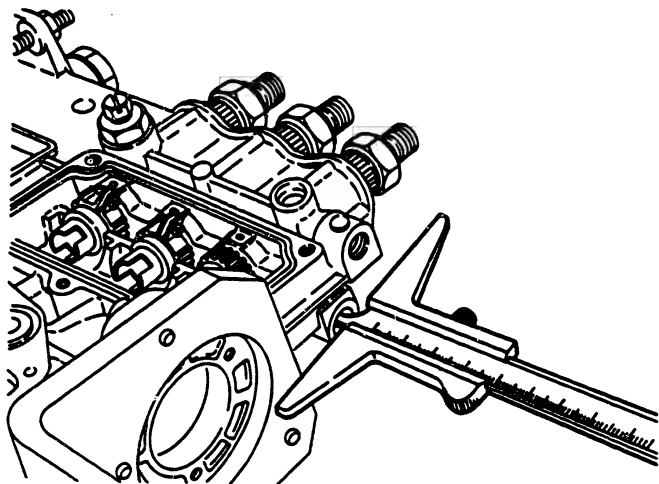


Fig. 76 Measuring control rack position at stop side

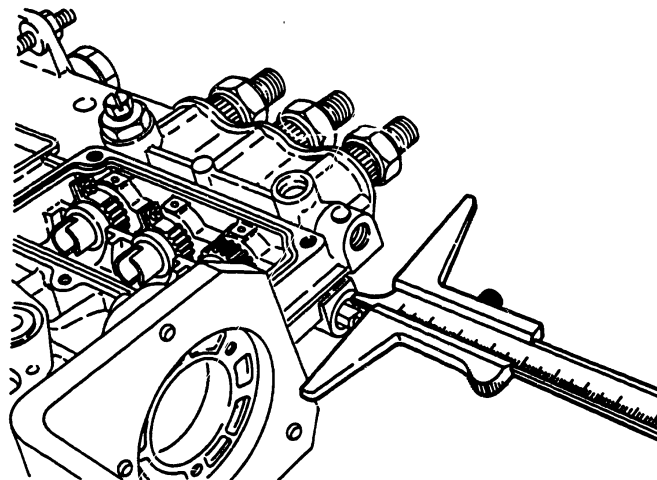


Fig. 77 Measuring control rack position at full side

- 6) Measure the distance between the end of the control rack and the pump housing end face with the control rack fully inserted (refer to Fig. 76). Then measure this distance when the control rack is fully protruding as shown in Fig. 77.

The sum of the two measurements should be between 14 and 14.6 mm.

**E2**

Reassembly

PES-K fuel injection pump

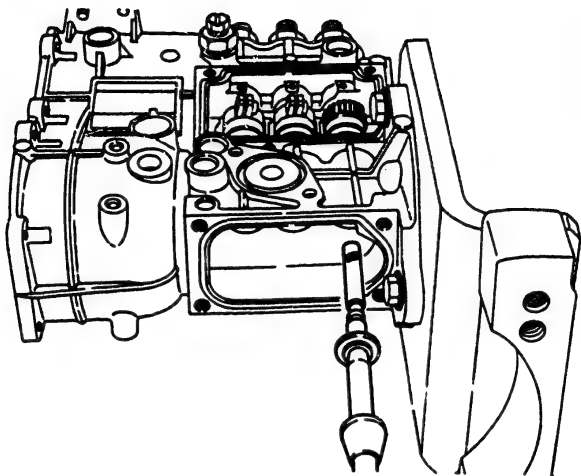


**E3**

Reassembly

PES-K fuel injection pump



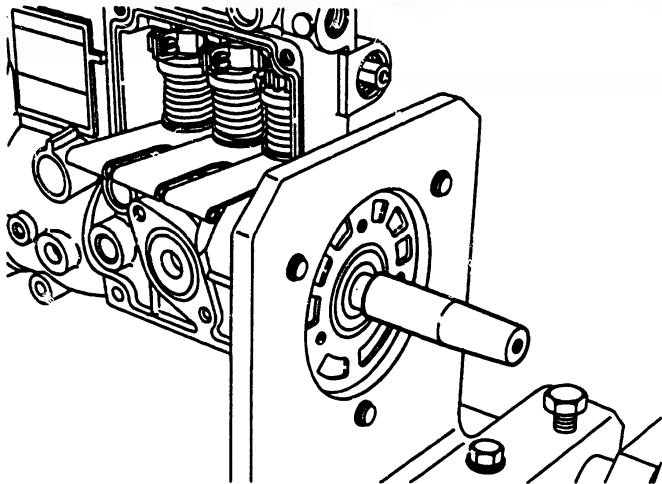


**Fig. 78** Inserting plunger

9. Gently insert the plunger into the plunger barrel with the helix in the plunger facing upwards, being careful to ensure that it does not touch other parts.

**Caution:** Ensure each plunger is kept with its corresponding plunger barrel, since they are machined as pairs with extremely high accuracy.

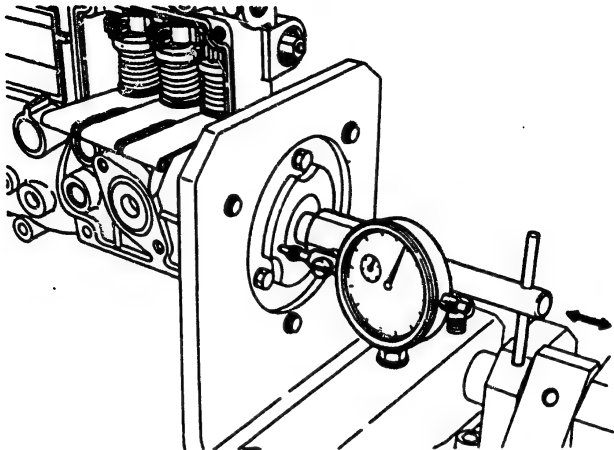




**Fig. 79 Attaching guide**

- 10. Observe the following precautions when attaching the bearing cover to the camshaft:**
- 1) Attach the guide (part no. KDEP 2874) to the end of the camshaft before attaching the bearing cover, so as to stop the oil seal lip being damaged by the key groove or threaded part of the camshaft.**
  - 2) Apply a small amount of grease to the guide (part no. KDEP 2874) and oil seal lip before attaching the bearing cover.**





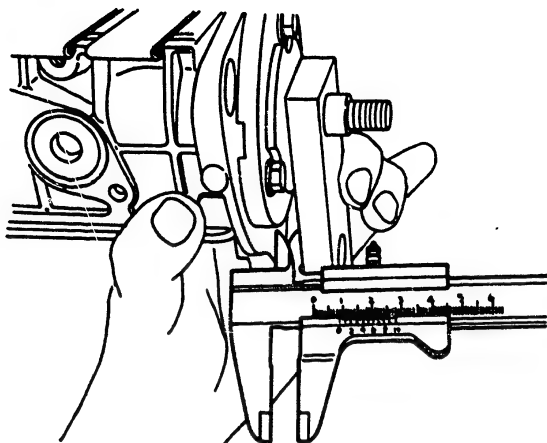
**Fig. 80 Measuring axial play**

11. Attach the measuring device (part no. KDEP 2890) to the threaded part of the camshaft. Measure the axial play of the camshaft. If the measurement exceeds the standard value, adjust the thickness of the shim (93) to bring the axial play within the standard value.

**Standard value of axial play:**

**0.03 - 0.05 mm**





**Fig. 81** Measuring position of tapered part of camshaft.

12. Remove the injection pump from the universal vice. Measure the position of the tapered part of the camshaft.

Attach the plate (part no. KDEP 2899) to the tapered part of the camshaft. Make sure that the distance between the plate end face and the pump housing end face is between 9.0 and 10.0 mm.

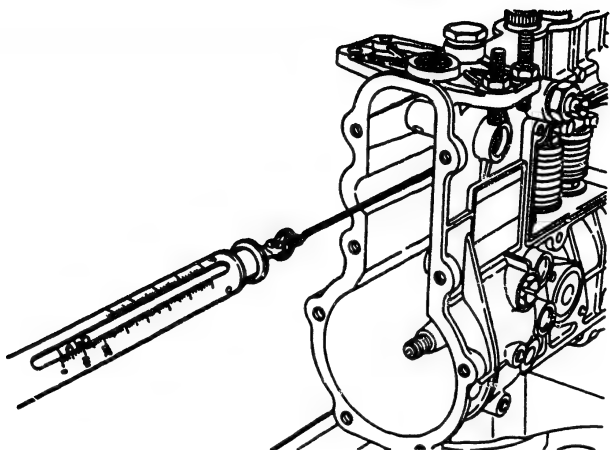


**Note:** If the distance is not within the above limit, replace the shims at the drive and governor sides in the following manner:

- 1) When the distance is less than 9 mm:  
Reduce the thickness of the shim at the drive side and increase the thickness of the shim at the governor side to make up the difference.
- 2) When the distance is more than 10.0 mm:  
Reduce the thickness of the shim at the governor side and increase the thickness of the shim at the drive side to make up the difference.
- 3) Check that the axial play of the camshaft is again within the standard value.





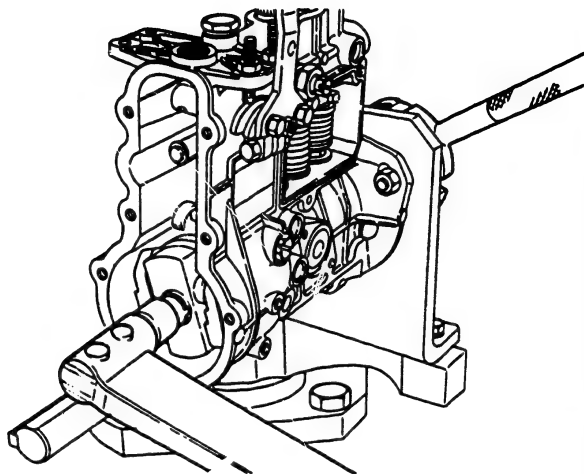


**Fig. 82**  
**Measuring resistance due to friction**

13. Measure the resistance due to friction when the control rack is being extended from the position where it is fully inserted (Fig. 82)

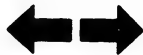
Pump speed	Resistance
0 rpm	150 g or less
100 rpm	50 g or less

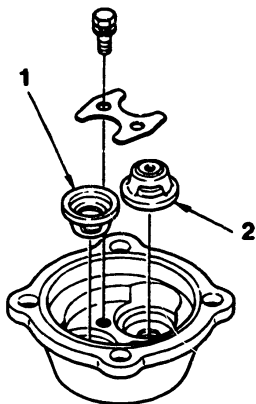




**Fig. 83 Tightening round nut**

- 14. Tighten the round nut of the flyweight holder to tightening torque of 2.0 - 2.5 kg-m.**





**Fig. 84 Check valve mounting**

- 1 = Check valve (supply side)**
- 2 = Check valve (suction side)**

**Supply pump**

- 1. Attach the check valves for the suction and supply ports in opposing directions as shown in Fig. 84 even though they are of the same type.**



## Check valve mounting

### Supply pump (continued)

2. After attaching the tappet, make sure that the guide pin does not protrude from the housing slit by rotating the tappet approx. 45° whilst pushing the diaphragm.
3. Attach the cover to the housing by securing the four bolts. The supply pump is now completely reassembled.

**E12**

Reassembly

PES-K fuel injection pump



**SPECIAL TOOLS FOR ADJUSTMENT**

After assembling the injection pump, it should be adjusted to satisfy the engine requirements using an injection pump test bench. The attachments and tools shown in Fig. 84 are necessary for the adjustments.

**Adjusting tools for PES-K pump**

No.	Part no.	Tool name	Qty	Application
1	1 688 010 011	Mounting stand	1	For mounting PES type pump (for test bench models 5 NP and 10 NP, shaft center height 110 mm)
2	1 688 010 129	Mounting stand	1	For mounting PES type pump (for test bench models 7 NP and 15 NP, shaft center height 125 mm)
3	KDEP 2611	Adapter	1	Used together with the mounting stands (nos. 1 and 2) ID: 74 mm and 76 mm
4	1 686 430 022	Coupling	1	For driving injection pump model PES-K
5	Comm. avail.	Lever	1	For manual flywheel operation
6	1 688 130 130	Measuring device	1	For measuring control rack travel
7	Comm. avail.	Box spanner	1	For connecting and disconnecting injection pipes (width across flats 17 mm)
8	Comm. avail.	Box spanner	1	For connecting and disconnecting injection pipes (width across flats 19 mm)
9	1 680 750 014	Injection pipe	3	Dia. 6 x Dia. 2 - 600 mm, M 14 x 1.5 - M 12 x 1.5
10	Comm. avail.	Wrench	1	Used when purging air from nozzle holder
11	0 681 343 009	Nozzle and nozzle holder	3	
12	0 681 440 014	Measuring device	1	For measuring plunger pre-stroke
13	0 681 440 006	Adjusting device	1	For measuring lever angle
14	KDEP 2636	Spanner	2	For tightening bolts and nuts
15	Comm. avail.	Eye	1	For connecting piping to test oil supply port
16	Comm. avail.	Gasket	2	For connecting piping to test oil supply port
17	Comm. avail.	Eye bolt	1	For connecting piping to test oil supply port

**E13**

Special Tools

PES-K fuel injection pump



**E14**

Special Tools

PES-K fuel injection pump



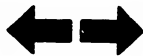
**Note:**

1. The required quantities for the injection pump model PES 3 K are described in the "quantity" column.
2. The tools (4, 12, 14, 15 and 16) are included in the kit (Part no. 105765-1270).
3. The test bench models 7 NP and 15 NP are provided with tools (Nos. 2, 3, 6, 7, 9, 10 and 11) as standard.

**E15**

**Special Tools**

**PES-K fuel injection pump**



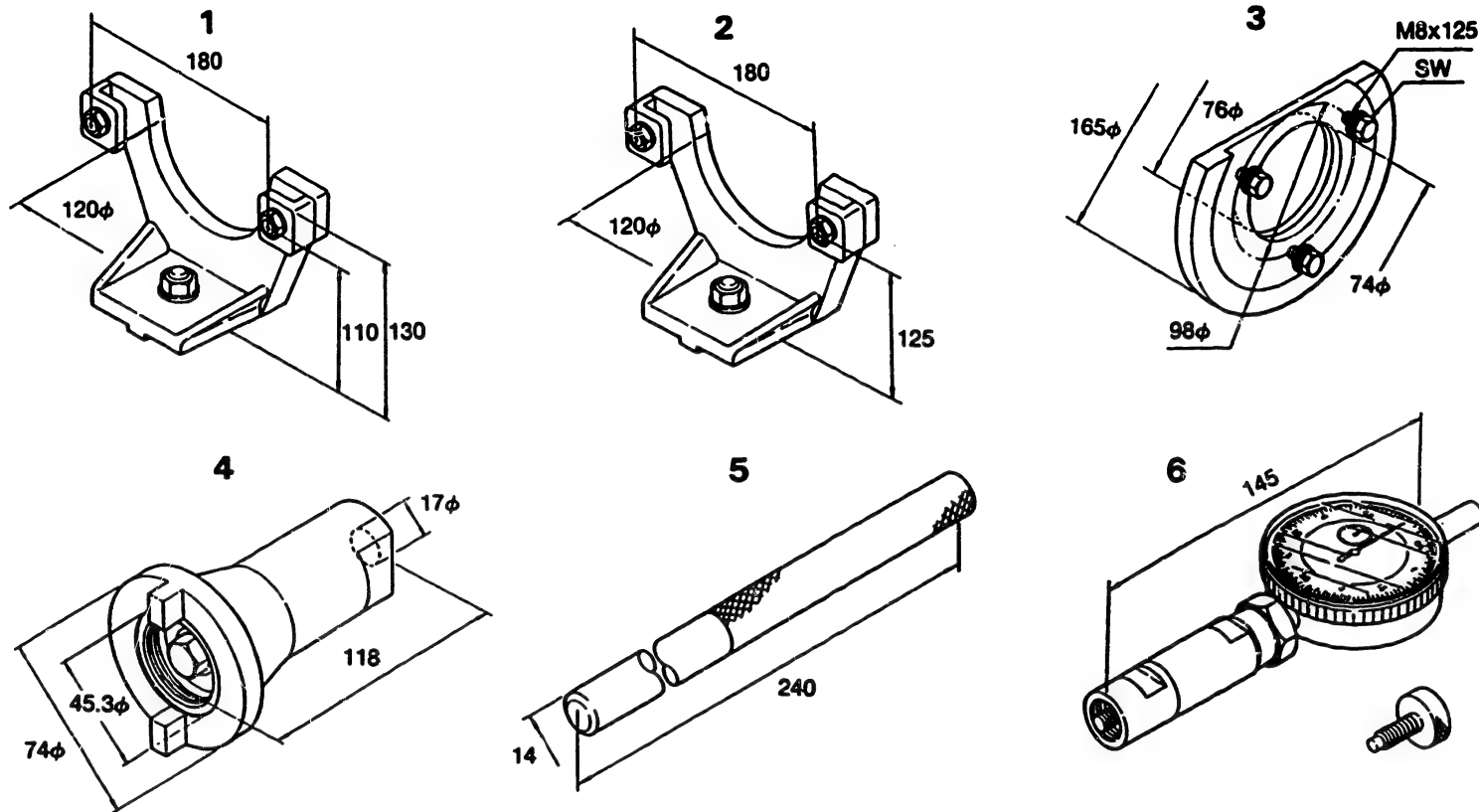


Fig. 85 Attachments and tools for injection pump adjustment

1 = Mounting stand

2 = Mounting stand

3 = Adapter

4 = Coupling

5 = Lever

6 = Measuring device

E16

Special Tools

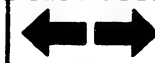
PES-K fuel injection pump



E17

Special Tools

PES-K fuel injection pump



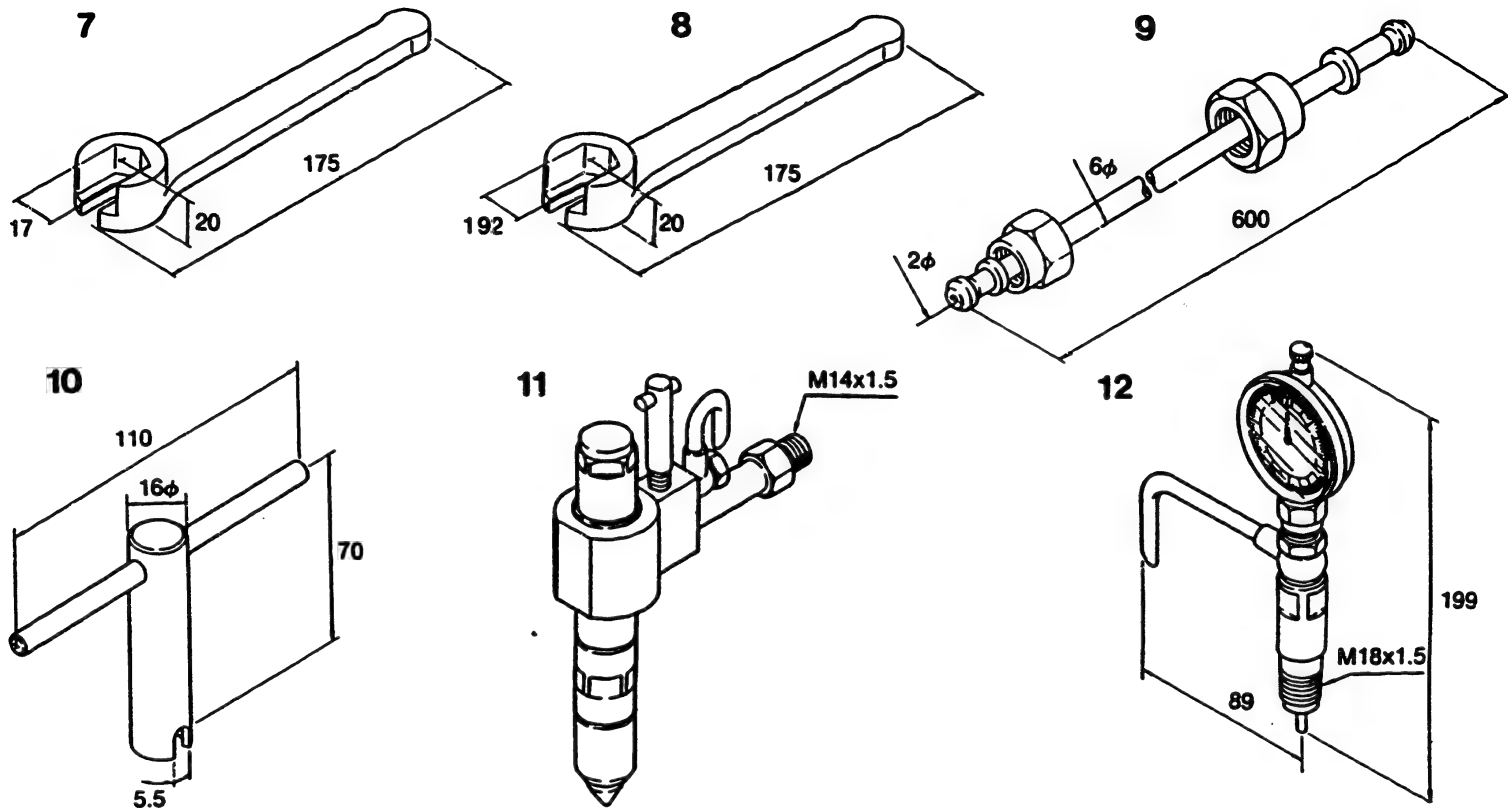


Fig. 85-1 Attachments and tools for injection pump adjustment

7 = Box spanner

8 = Box spanner

9 = Injection pipe

10 = Wrench

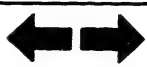
11 = Nozzle and nozzle holder

12 = Measuring device

**E18**

Special Tools

PES-K fuel injection pump



**E19**

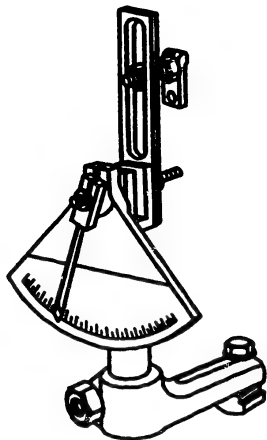
Special Tools

PES-K fuel injection pump

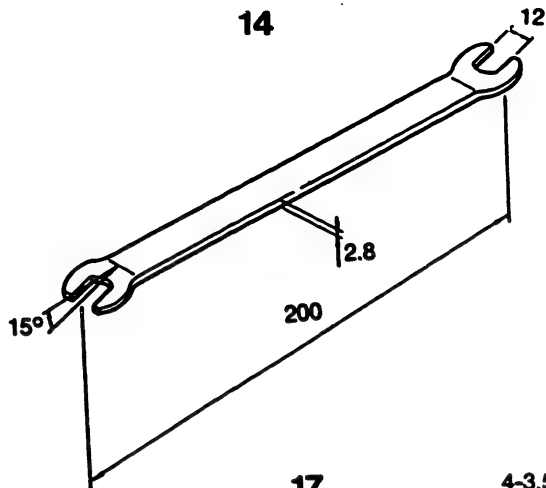




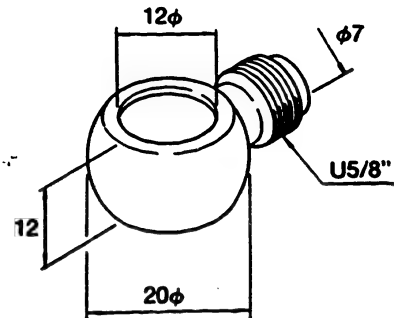
13



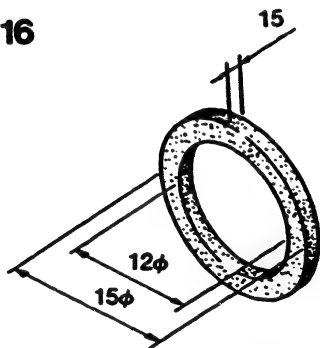
14



15



16



17

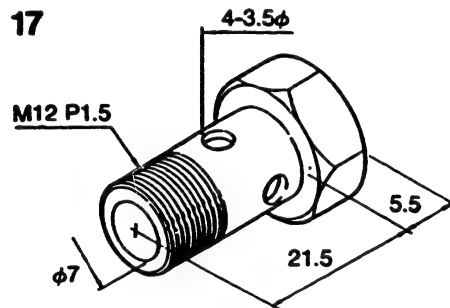


Fig. 85-2 Attachments and tools for injection pump adjustment

13 = Adjusting device

14 = Spanner

15 = Eye

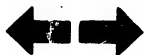
16 = Gasket

17 = Eye bolt

E20

Special Tools

PES-K fuel injection pump

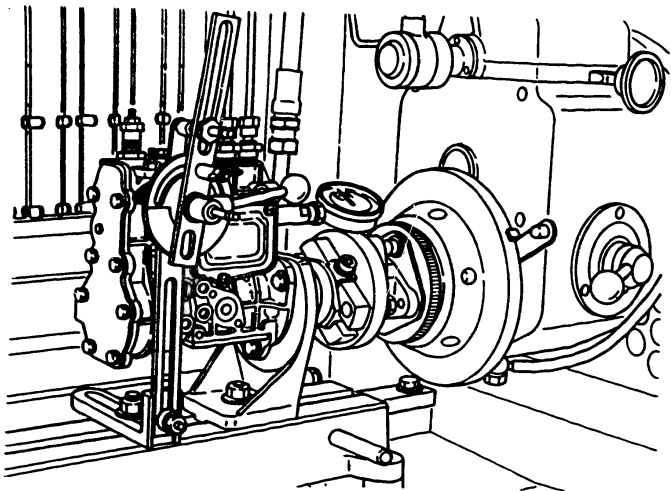


E21

Special Tools

PES-K fuel injection pump





**Fig. 86** Injection pump installed on the pump test bench

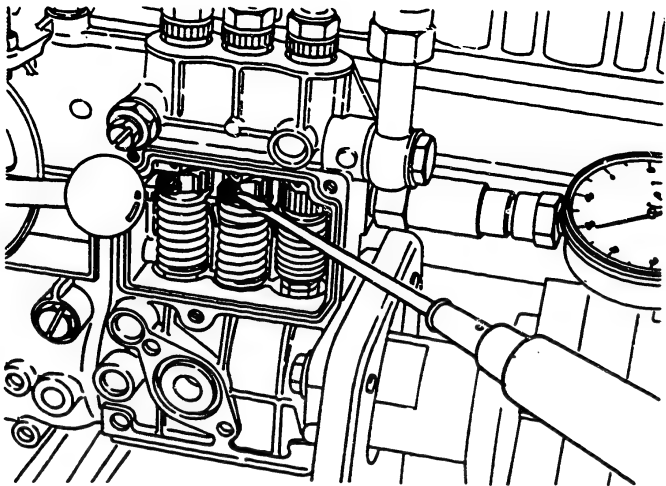
### **ADJUSTMENT**

#### **Preparation**

1. Install the injection pump on the pump test bench.  
Attach the measuring device (part no. 1 688 130 130) and adjusting device (part no. 0 681 440 006) to the control rack and control lever respectively.

**Note:** Refer to Pump Test Bench Operating Manual for operation of the pump test bench.





**Fig. 87** Adjusting control rack zero position

2. Adjust the control rack zero position. Set the measuring device indicator to the zero point with the control rack displaced to the governor side.
3. Check control rack movement and its full stroke.
  - 1) Make sure that the control rack moves smoothly by operating the control lever.
  - 2) Make sure that the control rack position is 13 - 14 mm with the control lever fixed in the full-speed position.



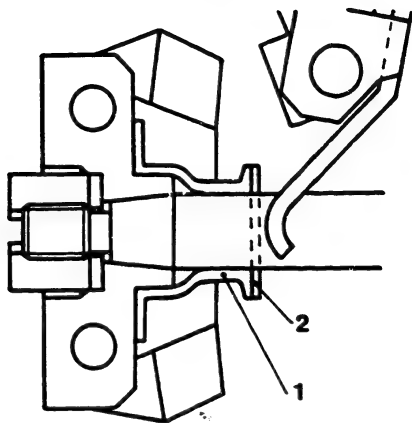


Fig. 88

1 = Sleeve  
2 = Shim

If the control rack position is not 13 - 14 mm, adjust the thickness of the shim (523) between the tension lever and the sleeve. The thicker the shim, the smaller the control rack measurement and vice versa.



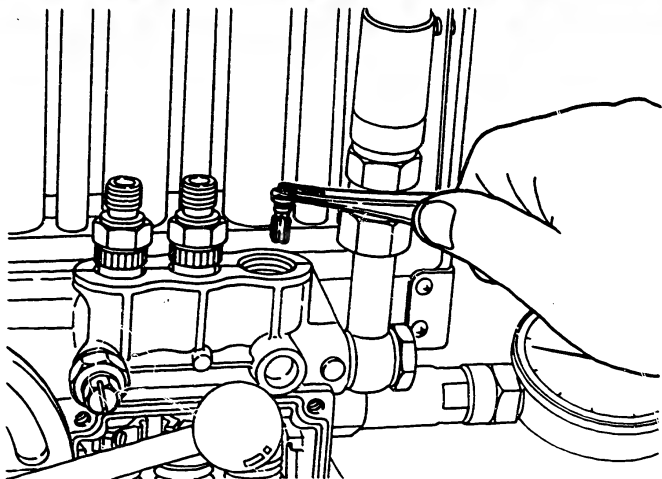
4. Supply approx. 110 cm<sup>3</sup> of pump oil (or engine oil) to the inside of the injection pump through the plug (570) hole or full-load stopper bolt (517) hole.
5. Loosen the screw (1/40) to purge air from the injection pump.
6. Prepare the service data for the injection pump (in accordance with the general assembly number).

**E25**

Adjustment

PES-K fuel injection pump



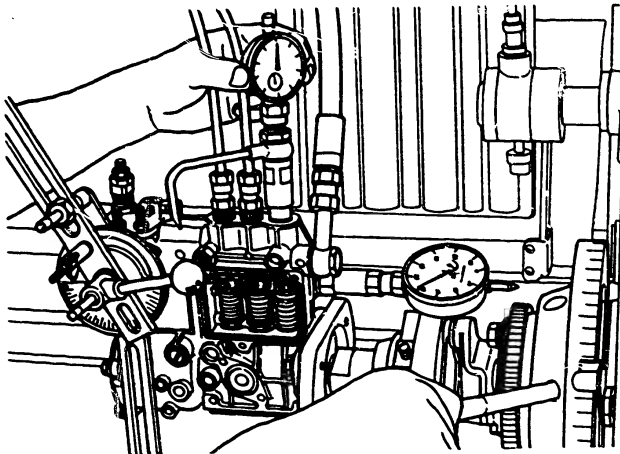


**Fig. 89** Removing delivery valve for No. 1 cylinder

#### Injection pump adjustment

1. Set the control lever to the full-speed position.
2. Remove the delivery valve holder, spring and valve for No. 1 cylinder.





**Fig. 90** Setting dial gauge indicator to 0 for No. 1 cylinder

3. Attach the measuring device (part no. 0 681 044 014) to the pump housing, then place the No. 1 cylinder cam in the bottom dead center and set the dial gauge indicator to 0.

**Note:** Rotate the camshaft by hand and make sure that the indication on the dial gauge indicator varies with the change in the cam lift.



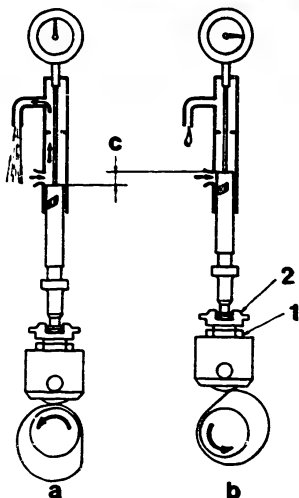


Fig. 91 Measuring pre-stroke

1 = Lock nut  
2 = Adjusting bolt

a = BDC  
b = Beginning-of-injection position  
c = Pre-stroke

4. Supply test oil to the injection pump at as low a pressure as possible:  
e.g.  $0.2 \text{ kg/cm}^2$ .





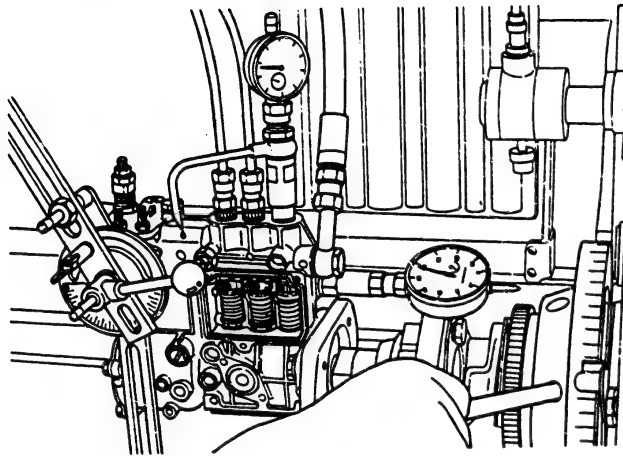


Fig. 92 Measuring pre-stroke

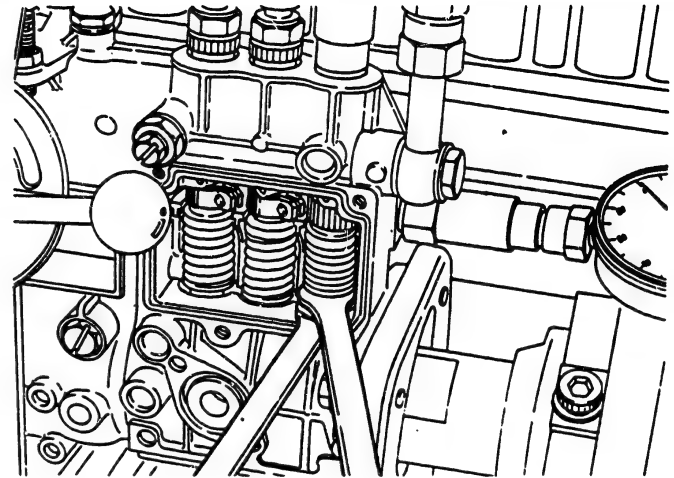


Fig. 93 Adjusting pre-stroke

5. Rotate the camshaft in the specified direction until the test oil stops flowing from the measuring device pipe.  
 Measure the lift (pre-stroke) of the No. 1 plunger.  
 If the pre-stroke is not within the specified value, adjust it in the following manner:
- 1) Loosen the roller-tappet lock nut.
  - 2) Adjust the position of the adjusting bolt.  
 If the pre-stroke exceeds the specified value, rotate the adjusting bolt counterclockwise and vice versa.  
 Measure the lift of the No. 1 plunger again.

**F1**

Adjustment

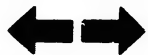
PES-K fuel injection pump

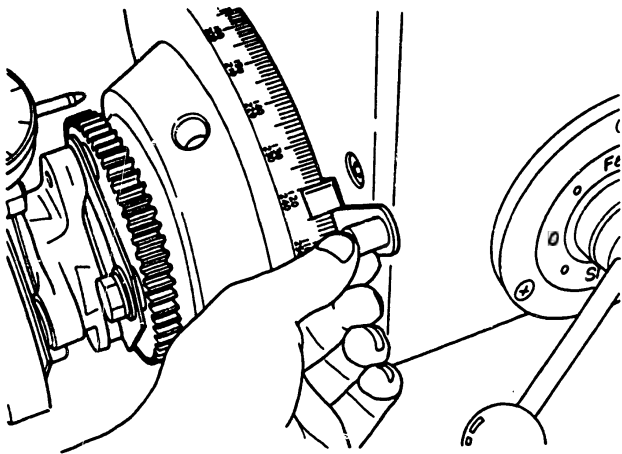


**F2**

Adjustment

PES-K fuel injection pump





**Fig. 94 Positioning pointer**

6. Set the pointer to an arbitrary angle graduation on the test bench flywheel with the camshaft placed in the beginning-of-injection position for the No. 1 cylinder.  
Make sure that the oil stops flowing from the measuring device pipe at this position.

**Caution:** Do not move the pointer after it has been set in the above position.



## Positioning pointer (continued)

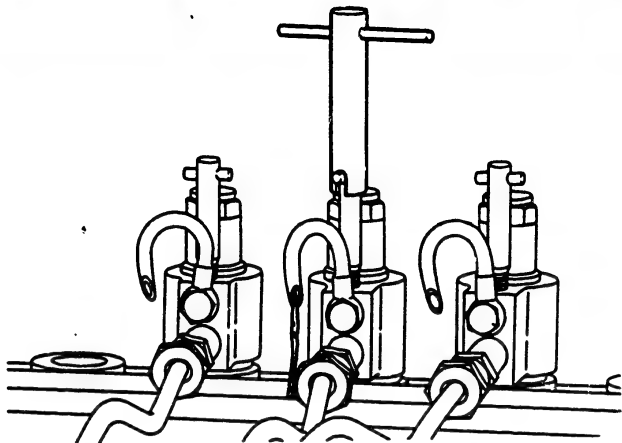
7. Remove the measuring device.  
Attach the delivery valve, spring and holder with gasket.  
Secure the delivery valve with holder at the specified tightening torque.
8. Attach the injection pipe to No. 1 cylinder.
9. Supply test oil at high pressure to the injection pump.

**F4**

Adjustment

PES-K fuel injection pump



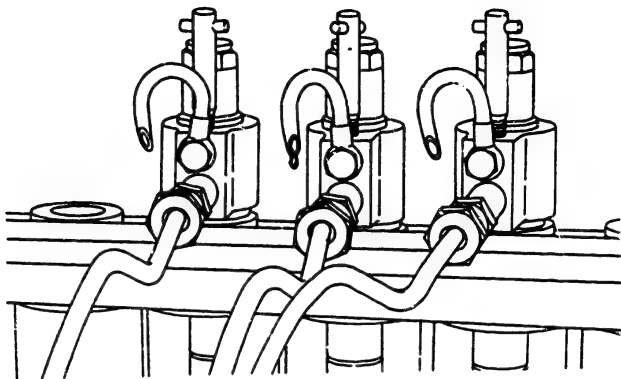


**Fig. 95** Opening nozzle holder valve

10. First open the nozzle holder valve such that the test oil flows out.

Measure the beginning-of-injection positions in the order of injection.



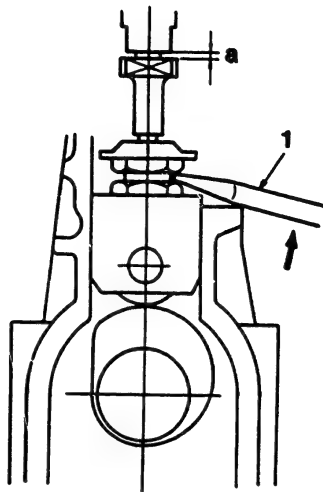


**Fig. 96** Measuring beginning-of-injection position

11. Rotate the camshaft until test oil stops flowing from the nozzle holder pipe.  
Read the pointer indication on the flywheel.

If the angle interval from the beginning-of-injection position for the No. 1 cylinder is not within specifications, adjust the position of the roller-tappet adjusting bolt.





**Fig. 97 Checking top clearance**

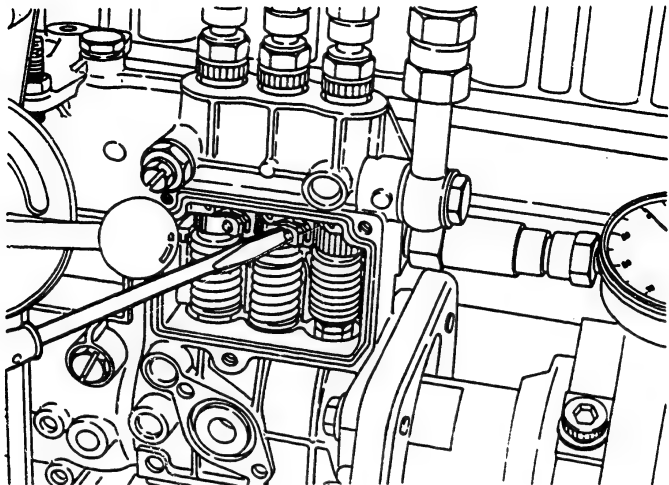
**1 = Screwdriver**

**a = Top clearance (more than 0.3 mm)**

**12. Checking top clearance**

Place the cams for each cylinder at the top dead center. Insert a screwdriver between the roller-tappet adjusting bolt and lock nut. Lift the roller tappet with the screwdriver and make sure that the top clearance is 0.3 mm or more. If the top clearance is less than 0.3 mm, adjust the pre-stroke again.





**Fig. 98** Checking control-rack zero position

**Injection quantity adjustment**

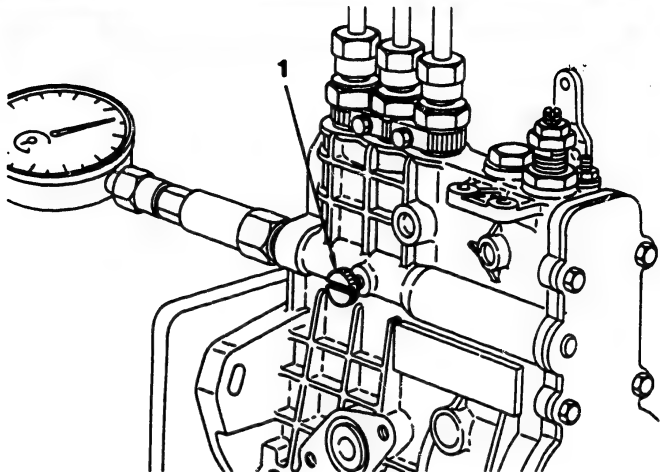
1. Check the control rack zero position.

**F8**

**Adjustment**

**PES-K fuel injection pump**





**Fig. 99 Attaching lock screw**

**1 = Lock screw**

- 2. Remove the control rack guide screw (522), then attach the lock screw (used to secure the control rack) to the pump housing in place of the guide screw.**





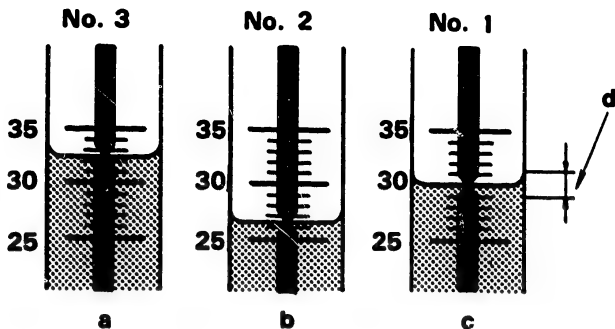


Fig. 100 Measuring fuel injection quantity

- a = Poor
- b = Poor
- c = Good
- d = Specified limits

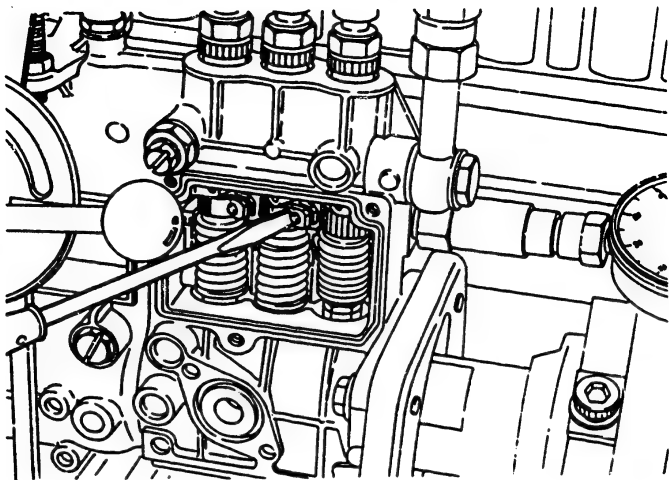
3. Measuring fuel injection quantity  
 Set the pump speed, control rack position and plunger strokes as specified in the service data. Measure the fuel injection quantity for each cylinder. If the fuel injection quantity is not within the specified limits, adjust it in the following manner:



4. **Adjusting fuel injection quantity**  
If the fuel injection quantity for the No. 1 cylinder differs from the quantities for the other cylinders, adjust the fuel injection quantities for the No. 2 and No. 3 cylinders (which can be adjusted) to that of No. 1 cylinder.
- 1) Move the control rack as far as possible to the pump drive side. Secure it with the lock screw.

**Caution:** Do not tighten the lock screw excessively, so as to avoid bending the control rack.

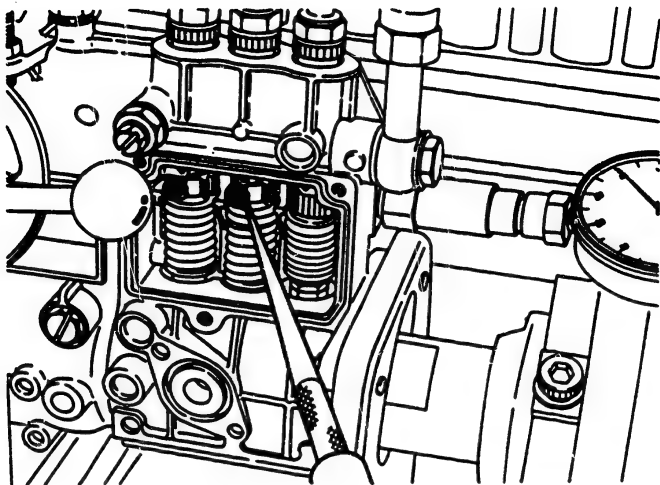




**Fig. 101 Loosening clamp screw of control sleeve**

**2) Loosen clamp screw of control sleeve.**





**Fig. 102 Fuel injection quantity adjustment**

- 3) Rotate the control sleeve clockwise or counterclockwise with an appropriate tool. Fig. 102 shows how the control sleeve is rotated to increase the fuel injection quantity.
- 4) Measure and adjust the fuel injection quantity in the same way as in 3 so that the fuel injection quantities for the No. 2 and No. 3 cylinders are the same as that for the No. 1 cylinder.
- 5) Make sure that the fuel injection quantities for each cylinder are within the specified limits under the other test conditions.



- 6) If the fuel injection quantity for the No. 1 cylinder is not within the specified limits, or if the fuel injection quantities for the other cylinders cannot be adjusted to within the specified limits, replace the plungers and delivery valves.
- 7) Attach the rack guide screw again.

**F14**

Adjustment

PES-K fuel injection pump



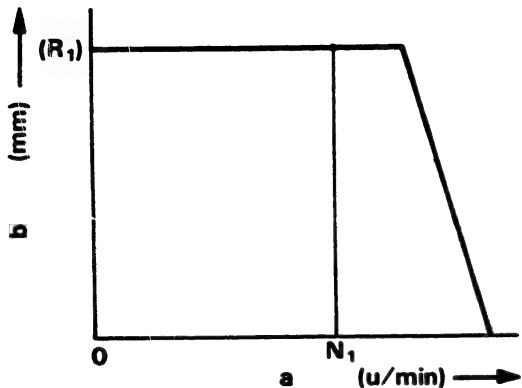


Fig. 103 Full-load rack position adjustment

a = Pump speed (rpm)  
b = Control rack position

#### Adjusting governor

##### 1. Full-load stopper bolt

- 1) Operate the injection pump at  $N_1$  rpm and set the control lever to the full-load position.
- 2) Adjust the position of the full-load stopper bolt to obtain the reference fuel injection quantity. In this condition, the control rack position  $R_1$  becomes the full-load rack position which is a reference for further adjustment.

Note: The control rack position when adjusting the fuel injection quantity is only a reference at that stage of adjustment.

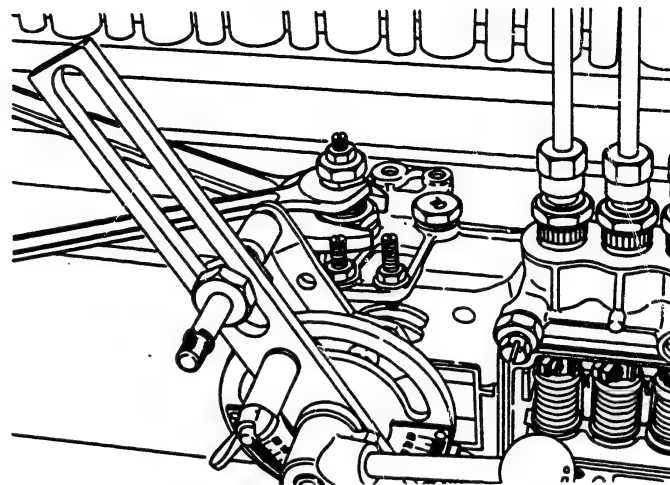
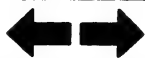


Fig. 104 Full-load stopper bolt setting

**F15**

Adjustment

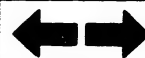
PES-K fuel injection pump



**F16**

Adjustment

PES-K fuel injection pump



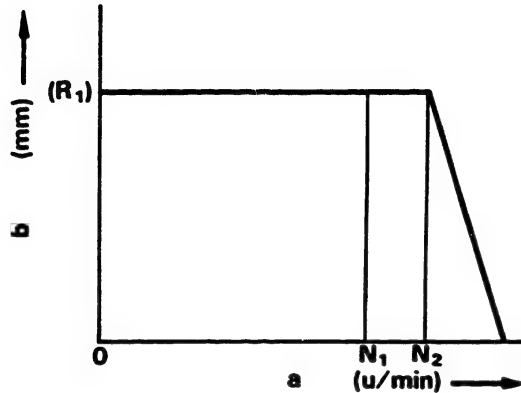


Fig. 105 Adjusting maximum speed

$a$  = Pump speed (rpm)  
 $b$  = Control rack position

2. Maximum speed adjustment

1) Set the control lever to the full-load position.

2) Increase the pump speed and set the maximum speed stopper bolt such that the control rack starts moving from position  $R_1$  towards 0 when the pump speed increases to  $N_2$  rpm.

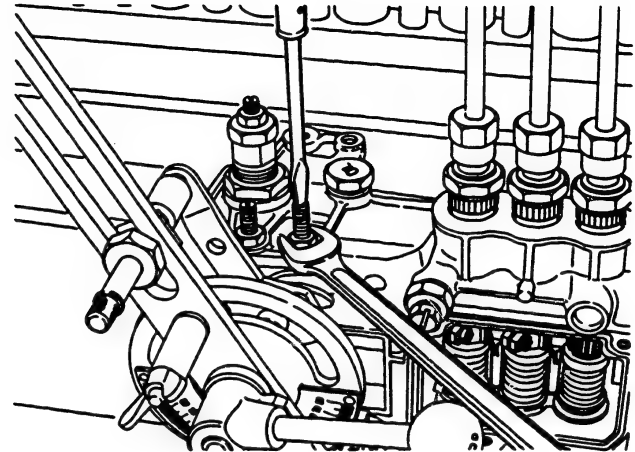


Fig. 106 Setting maximum speed stopper bolt

**F17**

Adjustment  
 PES-K fuel injection pump



**F18**

Adjustment  
 PES-K fuel injection pump



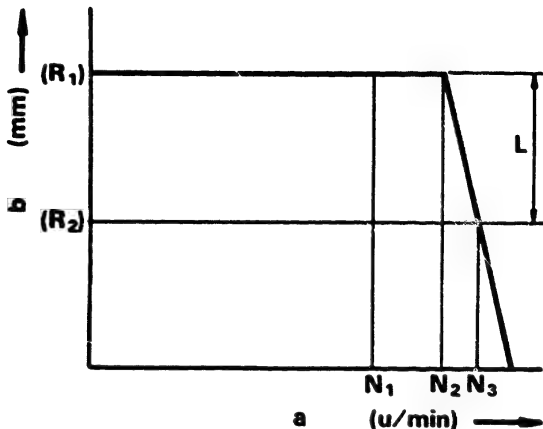


Fig. 107

a = Pump speed (rpm)  
 b = Control rack position

- 3) Check the speed droop (no-load maximum speed). Increase the pump speed further and make sure that the pump speed reaches N3 rpm when the control rack is moved to position R2 (R1 minus L).  
 If not, replace the governor spring.





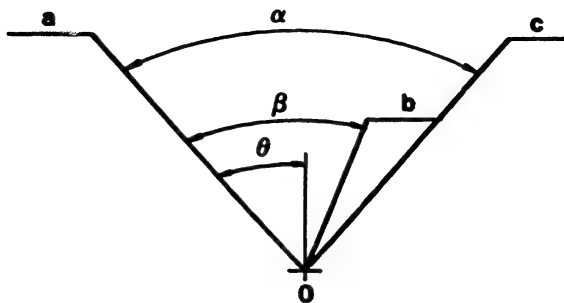


Fig. 108 Control lever angle

a = Full speed

b = Idling

c = Stop

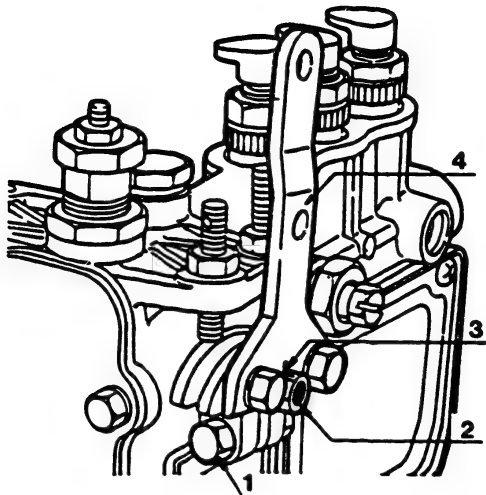
### 3. Checking control lever angle

Measure the control lever angle when the control lever is set to the full-speed position using the adjusting device (0 681 440 006).

If the control lever angle is not within the specified angle  $\theta^\circ$  (shown in Fig. 108), follow the steps below:

- 1) Set the control lever to  $\theta^\circ$ .





**Fig. 109 Control lever and related parts**

- 1 = Bolt**
- 2 = Shaft**
- 3 = Matching mark**
- 4 = Control lever**

- 2) Loosen the bolt (width across flats 10 mm) which secures the control lever to the shaft (503).**
- 3) Rotate the shaft clockwise or counter-clockwise so that the control rack starts moving from position R1 towards 0 when the pump is operated at a speed of N2 rpm. Tighten the bolt again (width across flats 10 mm).**



**Note:**

1. Mark the control lever and shaft to facilitate adjustment operations.
2. Repeat 2 ("Maximum speed adjustment").

**F22**

Adjustment

PES-K fuel injection pump



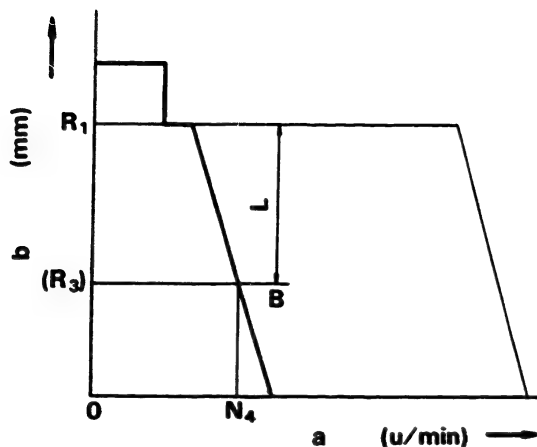


Fig. 110

a = Pump speed (rpm)  
b = Control rack position

4. Adjusting fuel injection quantity for idling operation

- 1) Maintain a speed of  $N_4 \text{ min}^{-1}$ .
- 2) Measure the fuel injection quantity and set the control rack to position  $R_3$  ( $R_1$  minus  $L$ ) where the specified quantity of fuel is injected.

Note: Position  $R_3$  is usually shown as "Adjusting Point B" in the service data.

- 3) Disconnect the adjusting device from the control lever so as to free the control lever.
- 4) Reduce the pump speed and maintain a speed of  $N_5$  rpm. Turn the idling spring guide until the control rack is moved to position  $R_3$ , then secure the guide with the lock nut (579).

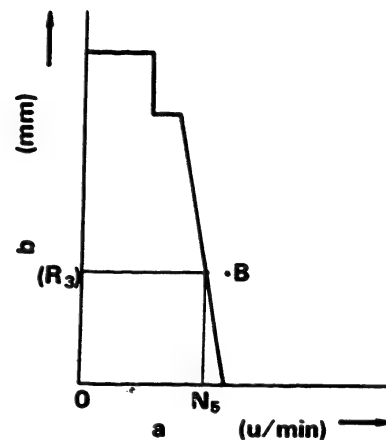


Fig. 111

a = Pump speed (rpm)  
b = Control rack position

F23

Adjustment  
PES-K fuel injection pump



F24

Adjustment  
PES-K fuel injection pump



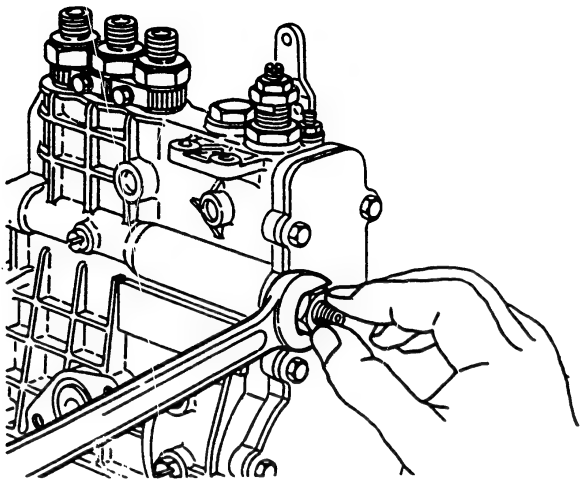


Fig. 112 Adjusting idling spring

**F25**

Adjustment

PES-K fuel injection pump



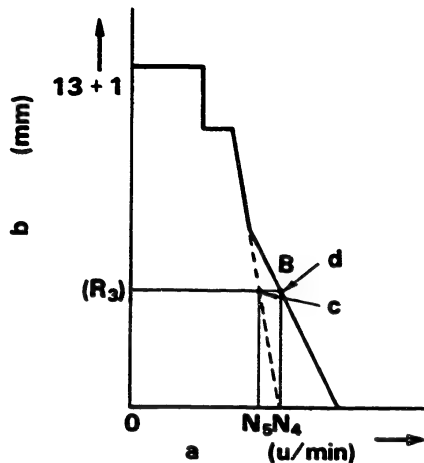


Fig. 113

- a = Pump speed (rpm)
- b = Control rack position
- c = Idling spring setting
- d = Main spring setting

- 5) Increase the pump speed again and maintain a speed of N<sub>4</sub> rpm.
- 6) Move the control lever so that the control rack is set to position R<sub>4</sub>. Temporarily secure the control lever in this position.
- 7) Gradually reduce the pump speed and make sure that the control rack moves smoothly and finally reaches the position "13 - 14 mm" (refer to Fig. 113).

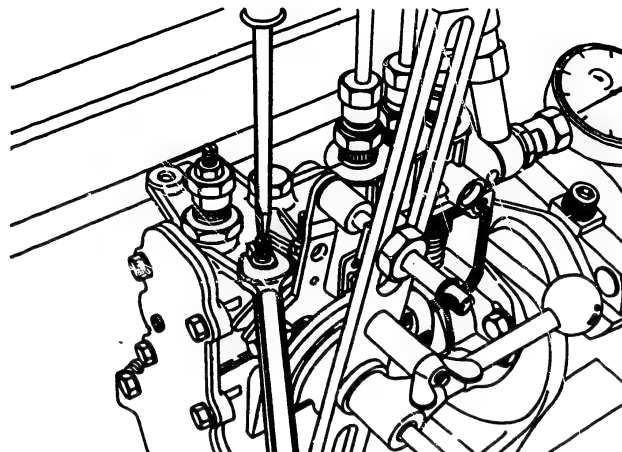
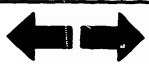


Fig. 114 Temporarily positioning control lever

**F26**

Adjustment  
PES-K fuel injection pump



**F27**

Adjustment  
PES-K fuel injection pump



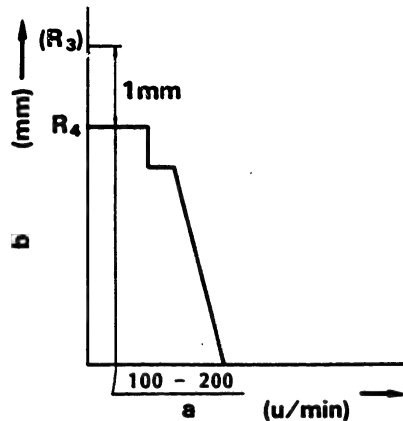


Fig. 115

a = Pump speed (rpm)  
 b = Control rack position

5. Adjusting stopper bolt

- 1) Operate the pump at a speed of 100 rpm. Move the control lever towards the stop position until the control rack is moved to position R4 (R3 minus 1 mm). Secure the minimum-speed stopper bolt.

Note:

- 1) With some models, the stopper bolt should be secured at "Adjusting point B". For details, refer to the descriptions given in the service data.
- 2) If a spring capsule type stopper is used, move the control lever further towards the stop position and make sure that fuel is no longer injected.

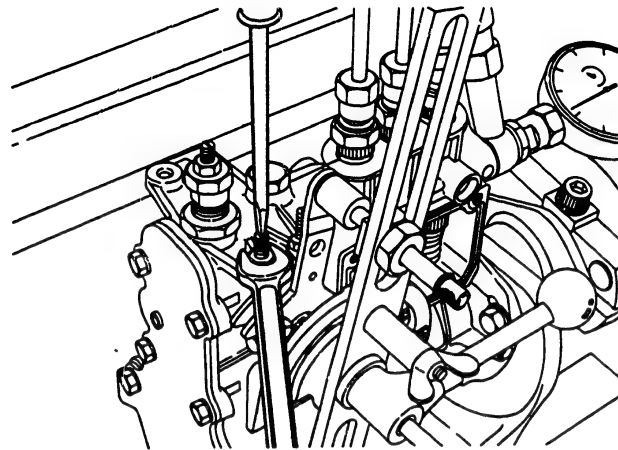


Fig. 116 Setting stopper bolt

61

Adjustment

PES-K fuel injection pump



62

Adjustment

PES-K fuel injection pump



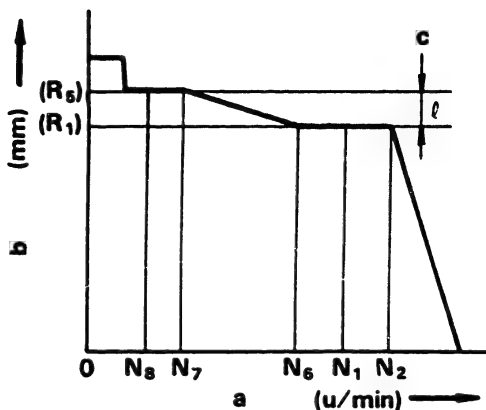


Fig. 117 Governor characteristics chart  
(with torque control device  
provided)

- a = Pump speed (rpm)
- b = Control rack position
- c = Torque control stroke

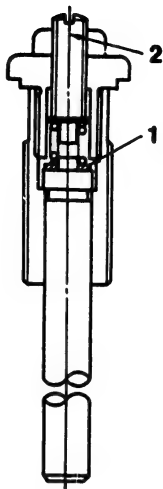
#### 6. Torque control device adjustment

Adjust the torque control device after adjusting the full-load rack position.

- 1) Set the control lever to the full-speed position. Then maintain the pump speed at a value between  $N_1$  and  $N_2$  rpm.







**Fig. 118** Cross-section of torque control device

1 = Adjusting shim  
2 = Adjusting bolt

- 2) Reduce the pump speed to N8 rpm. Make sure that the control rack moves in the fuel increase direction and that the torque control stroke (1) is within the specified limits. If not, adjust the thickness of the adjusting shim. If the stroke is less than the specified limits, reduce the thickness of the shim and vice versa.

**Note:** After adjusting the thickness of the shim, repeat steps 6.1) and 2).



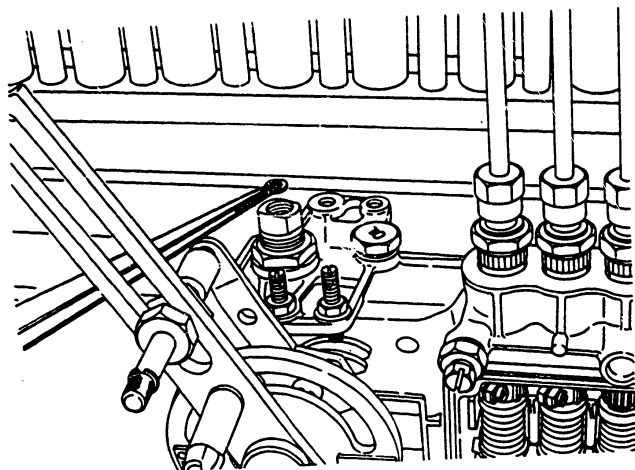


Fig. 119 Adjusting torque control stroke

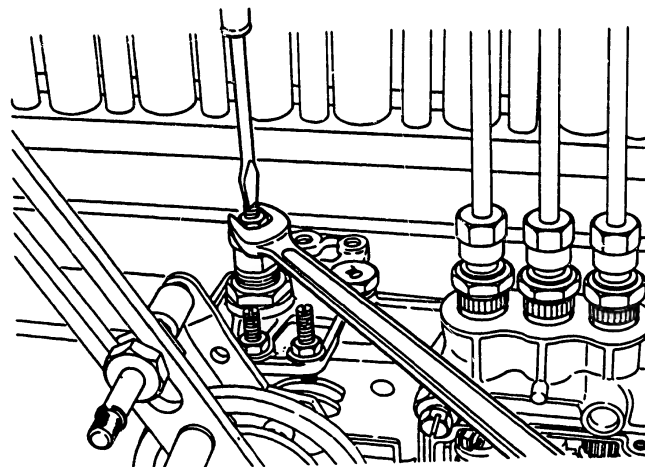


Fig. 120 Adjusting torque control spring

- 3) Gradually increase the pump speed and adjust the position of the adjusting bolt so that the compression of the torque control spring has begun when the pump speed reaches N7 rpm, and so that compression is complete when the pump speed reaches N6 rpm.

The above operations complete adjustment of the injection pump.  
To ensure proper operation, seal the appropriate parts.

65

Adjustment

PES-K fuel injection pump



66

Adjustment

PES-K fuel injection pump



## INSTRUCTIONS

### Fuel

Use the fuel specified by the engine manufacturer. The use of a low-grade fuel could adversely affect the engine and fuel injection device performance resulting in a shorter service life.

#### Adverse effects of low-grade fuel

1. As the nozzles, plungers and delivery valves are lubricated with fuel, any impurities in the fuel will accelerate component wear.
2. Low-viscosity fuel causes the nozzles, plungers and delivery valves to seize. High-viscosity fuel tends to form large particles when it is injected from the nozzles. Therefore it does not mix adequately with air and results in incomplete combustion.
3. Fuel with a high sulphur content produces a large amount of sulphur dioxide during combustion. The sulphur dioxide mixes with moisture in the combustion chamber and produces sulphuric acid which corrodes the nozzles and other parts.
4. Fuel which contains water causes the nozzles, plungers, delivery valves and other parts to seize and to rust.
5. Fuel which produces significant amounts of carbon residue results in carbon residue coating the nozzle tips and thus leads to poor fuel injection.



## Instructions (Continued)

### Sealing

1. After injection pump adjustments are complete, seal every adjusted part to ensure proper performance.
2. Never readjust the sealed adjusted parts without using the pump test bench.

### Lubricating oil

The camshaft and governor housing of the injection pump should be supplied with the specified amount of lubricating oil. In addition, the lubricating oil should be checked and changed periodically, since it is diluted with fuel which leaks from the plungers.



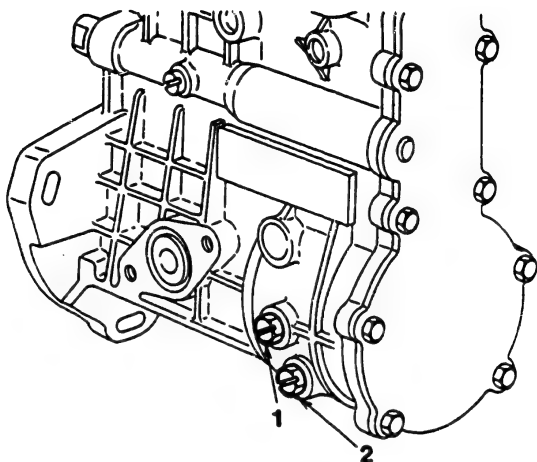


Fig. 121

- 1 = Lubricating oil level inspection plug  
2 = Drain plug

#### Checking and changing engine oil

Check that the engine oil level is as specified by the engine manufacturer. Unscrew the oil level inspection plug as shown in Fig. 121 and make sure that engine oil flows out. If the engine oil does not flow out, or if its viscosity is too low, remove the drain plug at the bottom to drain the engine oil out of the camshaft and governor housing. Remove the air breather, then supply the amount of lubricating oil specified on the name plate (or sufficient for oil to begin flowing from the lubricating oil level hole.



## TROUBLESHOOTING

The following are possible diesel engine malfunctions related to injection pump problems together with their causes and remedies.

Malfunction	Cause	Remedy
<b>Engine does not start</b>		
1. Supply pump does not supply fuel	<ol style="list-style-type: none"> <li>1. Empty fuel tank</li> <li>2. Clogged fuel pipe</li> <li>3. Damaged diaphragm</li> <li>4. Supply pump check valve does not function</li> <li>5. Supply pump tappet is stuck</li> </ol>	Supply fuel to tank Clean or replace Replace Replace
2. Supply pump supplies fuel, but injection pump does not inject fuel	<ol style="list-style-type: none"> <li>1. Filter element is clogged with foreign matter</li> <li>2. A large amount of air remains in the filter or injection pump</li> <li>3. Plunger is stuck</li> <li>4. Control rack is stuck at a small injection quantity position</li> <li>5. Delivery valve is stuck</li> <li>6. Faulty accelerator control lever connection with injection pump</li> <li>7. Broken injection pump coupling or coupling key.</li> </ol>	Clean or replace Purge of air Replace Repair or replace Replace Repair Replace coupling if it is broken. Replace gear and camshaft if key is broken. Repair or adjust timing
3. Incorrect pump setting	<ol style="list-style-type: none"> <li>1. Timing of injection pump operation is not correct in relation to engine operation</li> <li>2. Injection-pump roller tappet is worn excessively</li> <li>3. Camshaft is worn excessively</li> <li>4. Plunger is worn excessively</li> </ol>	Replace assembly Replace Replace

**G10**

Troubleshooting

PES-K fuel injection pump


**G11**

Troubleshooting

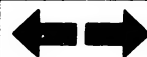
PES-K fuel injection pump



Malfunction	Cause	Remedy
<u>Engine starts, but it only operates for a limited time</u>	<ol style="list-style-type: none"> <li>1. Fuel pipe to injection pump is clogged or filter element is clogged</li> <li>2. Fuel contains air or water</li> <li>3. Air remains in injection pump</li> <li>4. Fuel pipe between fuel tank and supply pump is broken, or air is sucked into fuel pipe through incorrectly secured joint</li> <li>5. Supply pump does not function at its peak performance, causing insufficient fuel supply</li> <li>6. Ventilating device for fuel tank is clogged</li> </ol>	<p>Clean or replace</p> <p>Purge of air or fuel and change to high-grade fuel. Purge of air Replace fuel pipe Retighten the joint or replace packing. Faulty check valve seat</p> <p>Repair</p>
<u>Engine knocks</u>	<ol style="list-style-type: none"> <li>1. Injection timing is too early</li> <li>2. Nozzle opening pressure is excessively high</li> <li>3. Injection holes are slightly clogged (in the case of hole-type nozzle)</li> <li>4. Nozzle injection function has deteriorated</li> </ol>	<p>Readjust Readjust Clean or replace</p> <p>Replace</p>
<u>"Black smoke" and engine knocks</u>	<ol style="list-style-type: none"> <li>1. Incorrect pump adjustment with respect to engine</li> <li>2. Nozzle valve opening pressure is excessively low</li> <li>3. Nozzle spring is broken</li> <li>4. Nozzle injection function has deteriorated</li> <li>5. Plunger is excessively worn</li> <li>6. Faulty delivery valve seat</li> <li>7. Fuel injection quantity is too large and injection timing is incorrectly adjusted</li> </ol>	<p>Readjust</p> <p>Readjust</p> <p>Replace Clean or replace Replace Replace Readjust</p>



Malfunction	Cause	Remedy
<u>Uneven engine output power</u>	<ol style="list-style-type: none"> <li>1. Clogged filter element results in insufficient fuel supply</li> <li>2. Insufficient supply pump delivery</li> <li>3. Air remains in injection pump</li> <li>4. Fuel contains water</li> <li>5. Plunger tends to stick and it does not reach its full stroke</li> <li>6. Plunger spring is broken</li> <li>7. Control rack does not move smoothly</li> <li>8. Roller tappet does not move correctly or one part is excessively worn</li> <li>9. Delivery valve spring is broken</li> <li>10. Faulty sealing by delivery valve gasket due to insufficiently secured delivery valve holder</li> <li>11. Delivery valve does not function correctly</li> <li>12. Faulty nozzle injection function</li> <li>13. Nozzle needle valve does not move smoothly</li> <li>14. Nozzle valve spring is broken</li> <li>15. The nozzle valve opening pressures for each cylinder differ excessively</li> <li>16. Injection timing is not correctly adjusted</li> <li>17. Control lever does not contact full-load stopper</li> </ol>	<p>Clean or replace</p> <p>Replace check valve Purge of air Change to high-grade fuel Replace</p> <p>Replace Repair or replace Replace</p> <p>Replace Replace gasket and secure delivery valve holder to the specified torque Replace Clean or replace Replace Replace Readjust</p> <p>Readjust Adjust the rod length between accelerator pedal and governor control lever</p>
<u>Engine output is insufficient</u>  1. Insufficient fuel injection quantity	<ol style="list-style-type: none"> <li>1. The governor full-load stopper is not correctly positioned</li> <li>2. Control lever does not reach full-speed position</li> <li>3. Governor spring is stretched such that the governor starts functioning whilst the the engine is operating at a relatively low speed.</li> </ol>	<p>Readjust</p> <p>Readjust</p> <p>Readjust or replace</p>





Malfunction	Cause	Remedy
<p><u>Engine output is insufficient</u></p> <p>1. Insufficient fuel injection quantity</p> <p>(Continued)</p> <p>2. Nozzle spring is broken</p> <p>3. Engine knocks due to early injection timing</p> <p>4. Engine is overheated and black smoke is emitted due to late injection timing</p> <p>5. Nozzle injection function has deteriorated</p>	<p>4. Plunger is excessively worn</p> <p>5. Delivery valve gasket is damaged causing leakage (delivery valve holder is not secured correctly)</p> <p>6. Delivery valve seat is damaged</p> <p>7. Delivery valve is damaged</p> <p>8. Excessive amount of fuel leaks from nozzle</p>	<p>Replace</p> <p>Replace</p> <p>Replace</p> <p>Replace</p> <p>Replace</p> <p>Replace</p> <p>Readjust</p> <p>Readjust</p> <p>Clean or replace</p>
<p><u>Engine speed does not reach its maximum</u></p>	<p>1. Governor spring force is too weak</p> <p>2. Control lever does not reach full-speed position</p> <p>3. Nozzle injection function has deteriorated</p>	<p>Readjust</p> <p>Readjust</p> <p>Clean or replace</p>
<p><u>Engine maximum speed is excessively high</u></p>	<p>1. Control rack does not move smoothly</p> <p>2. Governor spring force is too strong</p> <p>3. Governor flyweight does not operate adequately</p>	<p>Repair or replace</p> <p>Readjust</p> <p>Replace</p>



Malfunction	Cause	Remedy
<p><u>Idling speed is unsteady</u></p> <ol style="list-style-type: none"> <li>1. Control rack does not move smoothly</li> <li>2. Fuel injection quantities of each injection cylinder differ excessively</li> <li>3. Plunger is worn excessively</li> <li>4. Plunger spring is broken</li> <li>5. Fuel contains air or water</li> <li>6. Governor idling spring force is too weak or incorrectly adjusted</li> <li>7. Excessive play between each governor link due to wear</li> <li>8. Flyweight bearing is worn excessively</li> <li>9. Supply pump supplies fuel incorrectly at low speed</li> <li>10. Insufficient amount of fuel at low speed due to clogged fuel element</li> <li>11. Nozzle injection function has deteriorated</li> <li>12. Injection timing is out of sequence</li> </ol>	<ol style="list-style-type: none"> <li>1. Plunger does not move smoothly or is stuck</li> <li>2. Control rack is not correctly connected to control sleeve</li> <li>3. Plunger spring is not seated correctly</li> <li>4. Clearance between plunger and lower spring seat is too small</li> <li>5. Faulty pump housing and plunger body</li> <li>6. Delivery valve holder secured with excessive torque</li> </ol>	<p>Replace Repair</p> <p>Replace Replace</p> <p>Repair or replace pump housing Secure delivery valve holder with specified torque</p> <p>Readjust</p> <p>Replace Replace Change to high-grade fuel Readjust Repair or replace Replace Measure the clearance between piston and supply pump body. Replace if not as specified Clean or replace</p> <p>Clean or replace Readjust</p>



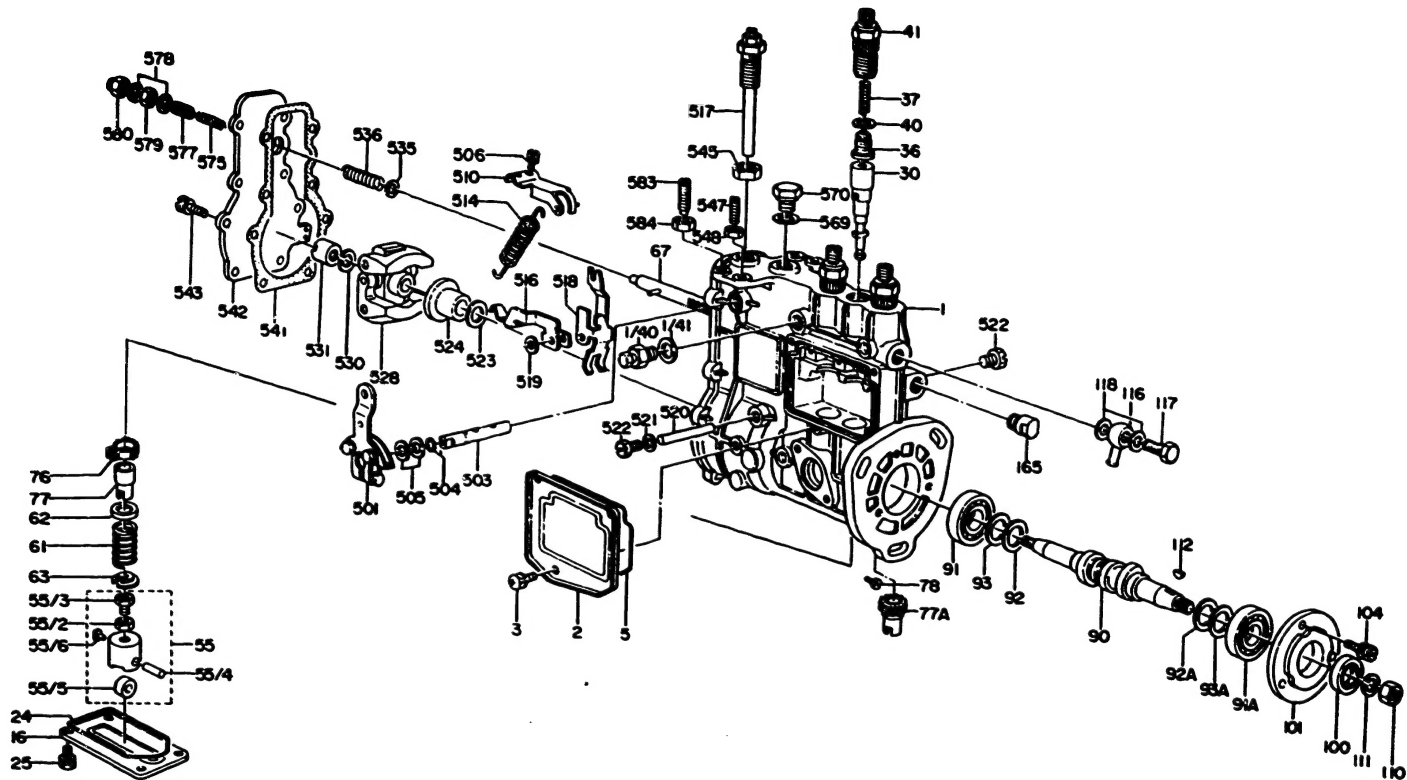


Fig. 122 Exploded view

# C O N T E N T S

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**N27**

Contents

PES-K fuel injection pump



**N28**

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PES-K fuel injection pump

